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**DECLINES IN STUDENT ACHIEVEMENT IN SCIENCE--  
IMPLICATIONS FOR PUBLIC EDUCATION**

by

**ROBERT P. HOGAN**

**A dissertation submitted in partial fulfillment of the  
requirements for the degree of Doctor of Education  
in the College of Education at  
the University of Central Florida  
Orlando, Florida**

**December 1990**

**Major Professor: Nannette McLain**

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by

Robert Patrick Hogan

## **ABSTRACT**

During the 1960s and 1970s, major innovative science curricula were introduced into public schools in the United States, and federal funds were used to improve the quality of science teachers. Nevertheless, student achievement in science has generally declined since 1963. This research focused on changes in four of the key variables related to science achievement--teachers, students, curricula, and school goals. The research examined (a) meta-analyses of the effectiveness of the innovative science curricula on student achievement, (b) research on changes in teacher and student characteristics during the last 30 years, (c) educational literature on changes in the goals of public education during this same period, and (d) changes in student achievement.

The results of this research suggest that the recent declines in science achievement are related to changes in student motivation, school goals, and school autonomy. The data indicate that contrary to the claims of some recent education commission reports, teachers and curricula have improved steadily over the last three decades. The conclusions developed from this research suggest that a number of the current educational reforms such as teacher competency testing, merit pay, curricular reform, student competency testing, and year-round schools should have little positive effect on student achievement. The research also suggests that parental



**involvement in education could have a negative influence on science achievement. The findings do suggest that schools of choice, corporate educational partnerships, and teacher empowerment could significantly improve student science achievement.**

**To my wife Rosemary for her love and support**

**Ubi coniciebamur pollicitus eram semper flores--**

**Ver jam appetet**

## **ACKNOWLEDGEMENT**

**To Dr. Nannette McLain**

**An anonymous Soviet poet wrote:**

**While yet there is time  
Look out upon the world; devour it with your eyes  
And, if your spirit demands more  
add at least one stone to the edifice being built  
So that when you are gone everyone will know  
that where you once were a great emptiness now yawns.**

**Thank you for adding this small stone. Without your unerring guidance and untiring patience, this dissertation would still be an intention. And thank you for your wonderful sense of humor. It helped to make this effort fun.**



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## CHAPTER 1

### INTRODUCTION

Following World War II, the United States was thrust into the *age of technology*. Scientific discoveries and technological advances stimulated by the war effort, as well as the transition to a peace-time economy, created a demand for new goods and services. Within the span of a few years, Americans were introduced to television, jet planes, and a whole assortment of labor-saving devices. Within the American home, scrub tubs were replaced by washing machines, clothes lines yielded to electric dryers, and coal bins disappeared as they were replaced by oil tanks.

During this same period, the Korean War and the "Cold War" demonstrated the importance of developing new military technology to keep the world "safe for democracy." Americans came to believe that technological innovation was essential to keep ahead of the Soviets.

The country was enamored with science and technology. After all it had helped to win the war, made the United States the dominant world leader, and promised to eliminate world hunger and poverty. Science and technology held the promise of offering a standard of living undreamed of by previous generations. The American public came to believe that today's dreams were tomorrow's inventions.

And why not? Submarines and rockets, the fare of earlier fiction writers, were the reality of the mid-1900s.

The combination of the peace-time economy, the military threat, and the American love affair with science and technology created a sudden demand for scientific talent--a demand that public schools could not meet. The last element in this chain of events leading to a major reform of science education in the United States was the launching of Sputnik in 1957. The idea that the Soviet Union could threaten our national security from space, as well as the national embarrassment that their German scientists were better than ours, pressed the United States into a national race for space.

The reform of science education had begun during the early years of the Eisenhower administration. However, when Sputnik was launched, more funds were dedicated to public elementary and secondary education. Federal funds were used to provide science teachers with additional training. Between 1959 and 1972, the National Science Foundation (NSF), a federal agency established by Congress in 1950, allocated approximately two-thirds of its budget for the creation of innovative science curricula in grades 7 to 12 (Weinstein, Boulanger, & Walberg, 1982). The educational reforms led to new methods of instruction and major innovative science curricula were introduced into public schools in the United States during the 1960s and 1970s.

Nevertheless, in spite of the massive educational funding effort, student achievement and interest in science generally declined between 1963 and 1980. The



report *High School and Beyond: A National Longitudinal Study for the 1980s* (1985)

began as follows:

Over the last 20 years, the United States has witnessed a widespread decline in the quality of education. This decline has been especially pronounced with respect to mathematics and science, as evidenced by lowered enrollments and achievement scores, a diminishing teacher pool, and increased numbers of students on a general education track. (p. xiii)

During the 1980s, a national concern for declining student achievement led to nationwide educational reforms. Despite these reforms, national and international indicators of science and mathematics performance of students in the United States still showed little improvement (National Science Board, 1990).

This research investigated the effects of changes in the focus of educational reforms, societal changes, and changes in the American family on teacher quality, curricula, student characteristics, and school goals. The research then investigated which of these factors--curricula, teacher quality, student characteristics, or school goals--were most closely linked to changes in student achievement in science between 1957 and 1990. Based upon these findings, some implications for public education are discussed. The report also discusses the expected effectiveness of some of the recent educational reform proposals. Finally, some recommendations are proposed for educational reforms that could possibly improve student achievement.

### **Background**

The launching of Sputnik in 1957 jolted the American public into a willingness to provide federal funding for educational reforms to train skilled scientists and

engineers. The results of these reforms were soon evident. By 1963 the Scholastic Aptitude Test Mathematics scores (SAT-Ms) reached their highest level, and in 1969 the United States placed men on the moon.

Yet, in the 1970s sharp declines in science achievement, which were part of a broader pattern of decline in overall achievement levels, led educators to once again voice concerns about the quality of public education in the United States. By 1980 these concerns were replaced by warnings of a crisis in education (Yager, 1980); and in 1983 the condition of the nation's public schools became a national concern when the National Commission on Excellence in Education released the report, *A Nation at Risk: The Imperative for Reform, A Report to the Nation*.

The report declared that schools were failing in their efforts to educate students. According to the report, "We are raising a new generation of Americans that is scientifically and technologically illiterate." (p. 10) The widely published report instigated a national effort to reform public education. This effort, however, was not the first, but the fourth, national effort begun within 30 years to reform public education in the United States.

A series of reports including *A Place Called School* (1984), *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science, and Technology Education for all American Elementary and Secondary Students so that their Achievement is the Best in the World by 1995* (1983), *High School* (1983) *The Paideia Proposal* (1982), and *Horace's Compromise* (1984) confirmed the fears of educators and the public that public schools were not providing quality education,



especially in science and mathematics. Appendix B contains a listing of major educational reports on the state of public education between 1975 and 1990.

More recent studies have questioned the science ability of American students compared with students in other countries. Six countries--Canada, Ireland, Korea, the United Kingdom, the United States, and Spain--participated in the International Assessment of Educational Progress (1989). In this study, selected questions from the 1986 National Assessment of Educational Progress test were used to test 13-year-olds' science and mathematics achievement. On this test, students in the United States performed poorly, ranking behind students in Spain, Canada, the United Kingdom, and Korea.

Recent surveys indicate that the crisis in science education is twofold--not only do American students rank poorly in science achievement compared to their peers in other countries, but also American students are not interested in choosing careers in science and engineering. According to the National Science Board report, *Science and Engineering Indicators--1989*, 20% of United States graduates received science and engineering degrees in 1986, compared to 27% in Japan and 34% in West Germany, 40% in the United Kingdom, and 48% in France. Tifft (1989) reported that in 1988, one third of all United States Ph.D.s in natural science and engineering were earned by foreign students, that less than 1% of college freshmen reported that they intended to major in either mathematics or physics, and that, by the year 2000,



the United States will face shortages of between 450,000 and 750,000 scientists and engineers.

Recent studies, such as the National Science Board report, *Educating Americans for the 21st Century*; the 1984 National Academy of Science report, *High School and the Changing Workplace: The Employer's View*; and the 1983 Education Commission of the States report, *Action for Excellence: Task Force on Education for Economic Growth* point out the serious problems faced by public schools.

### **Significance of the Decline in Science Achievement**

Today's world economy is driven by technological innovation, and those countries with the best scientists and engineers will most likely control this economy (Welborn, 1984; Altbach, 1985). The National Center for Education Statistics 1989 report, *Education Indicators*, opens:

Since the early 1980s, the country has become increasingly aware of the range of critical issues facing its schools. These issues are nationwide and include problems of declining academic performance, concerns about teacher qualifications and availability, and use of drugs and violence in the schools. The issues have serious implications, not only for effective operation of the schools, but for the future of individual workers, U.S. economic competitiveness, and ultimately for the structure and cohesiveness of American society. (p. 3)

The economic competitiveness of the United States has been challenged by foreign nations. According to Dentzer (1990), in the last 20 years the percentage of American-produced home electronics purchased in the United States has dropped from nearly 100% to a mere 5%. Japan threatens to monopolize the production of advanced computer chips and is a world leader in robotics. As of 1986 the United



States was replaced by Japan as the leading exporter of high-technology products (*National Science Board, 1989*). Korea has constructed state-of-the-art computer-driven steel mills that turn out higher quality, cheaper steel than can be produced in American mills. German manufacturers continue to capture increasingly larger shares of the high technology American market.

Unless American schools improve the quality of science education and increase the numbers of scientists and engineers, European and Asian countries may continue to increase their share of world economic markets at the expense of the United States. At the present time, projected shortages of trained scientists and engineers by the year 2000 could threaten not only the nation's economy but also our national security (*A Nation at Risk, 1983; Weiss, 1985*).

In the 1990s and beyond, not only must the United States produce highly trained scientists and engineers, but also blue- and white-collar workers who understand the principles of science. In a *U.S. News & WORLD REPORT* article (Dentzer, 1990), Robert Reich, who teaches public policy at Harvard, said, "I've heard officials of foreign firms say, 'Don't quote me, but we have to simplify our machinery and dumb down our training and orientation programs for workers in the U.S.'" Dentzer added:

New production techniques require decision making by even the lowliest worker, while modern quality control demands a knowledge of statistics common among Japanese high-school graduates but rare among many U.S. college students. (p. 26)

It is not enough, however, for the United States to develop skilled scientists and engineers and scientifically educated workers in the United States. Our

continued economic and social growth depends upon public science literacy (*National Science Board*, 1989; Lapointe, Mead, & Phillips, 1989). Only a scientifically competent citizenry can make responsible decisions on issues related to nuclear energy, global warming, extinction of species, and acid rain, as well as ethical questions surrounding certain medical advances in genetics and the prolongation of life.

### **The Lack of Consensus**

There is no consensus on the nature of or the solution to the current educational problems. The various groups of educational reformers have been unable to identify a common set of factors related to the declines in science achievement. For example, Tifft (1989) reported that the solution to the current educational problems is to increase funding dramatically and to improve science teaching methods. National educational reports such as *Action for Excellence: Task Force on Education for Economic Growth* (1983), *A Nation at Risk* (1983), and *Making the Grade: Report of the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education Policy* (1983) by the Twentieth Century Fund assert that teacher salaries are the key to teacher performance and therefore to student achievement.

According to many of these reports, by attaching salary incentives to teaching performance, teachers will strive to excel in their teaching. Kelly (1985) sums up the rationale behind higher salaries and merit pay, stating that "more intelligent



individuals will be attracted to the profession, and the problem of excellence will thereby be resolved."

Other educational critics claim that the solution involves greater emphasis on teaching higher order thinking skills, especially critical thinking, in place of memorization (Arter, 1987; Elman & Lynton, 1985). Still others, such as United States Secretary of Energy James D. Watkins and American Federation of Teachers President Albert Shanker, argue that funding is not the issue. Instead, they claim that better curricula are needed and that teachers and teacher organizations know what curriculum is most effective (Tifft, 1989). In contrast, the report, *A Nation at Risk* (1983) cited teacher incompetence. According to the report, half of the nation's science teachers were not qualified to teach their subjects.

Altbach (1985) offers a very different explanation of the current crisis in education. Altbach argues "Thus, the crisis in education is caused directly by social policy and public opinion." (p. 15)

The variety and range of proposed solutions have grown as the inability of schools to restore science achievement has become more evident. More modest reforms include longer school days, an increased school year, testing of students and teachers, and increased graduation requirements, which include more courses in mathematics and science. More extreme solutions include year-round schooling, magnet schools, and schools of choice, as well as proposals to completely restructure schools (Sizer, 1983; Chubb & Moe, 1990). One recent experiment has turned over the control of public schools in Chicago to local citizen committees (Tifft, 1990).

### **The Need for Answers**

One of the effects of the declines in student achievement in the 1960s and 1970s was that schools and teachers came to be viewed by the public and legislators as the likely cause of the problem. Consequently, many of the educational reforms have been directed at teachers.

But what if the declines in student achievement in science are not related to changes in teacher quality? Some reports have cited changes in the attitudes, motivation, and behavior of students as a cause of the decline in science achievement (Lapointe, Mead, & Phillips, 1989; Carnegie Foundation for the Advancement of Teaching, 1990)). Other reports (Applebee, Langer, & Mullis, 1989) have stressed the need to redefine school goals.

All parties involved in education--teachers, administrators, parents, school boards, and state and federal governments--need to understand the causes for the current crisis in science education in order to find solutions (Kavale, 1988). The proposed educational solutions vary greatly depending upon which of these factors is perceived as being the cause of the declines in science achievement. Unless the principal factors responsible for declining science achievement are isolated, time, effort, and large amounts of money may be wasted trying to implement illusionary solutions. But more importantly, the nation is at a critical juncture, and the road



taken into the next century will depend upon the quality of our science programs in public schools.

### **Focus of Research**

There is an unanswered question concerning educational reform and science achievement. Why is it that tougher standards for teachers and students, longer school days, a longer school year, and more science and mathematics courses required for graduation have not produced the expected gains in science achievement? How is it that competency testing, compensatory education, innovative science curricula and instructional strategies, computer-based instruction, and increased funding for schools have not enabled students in the United States to do well in international tests of science achievement?

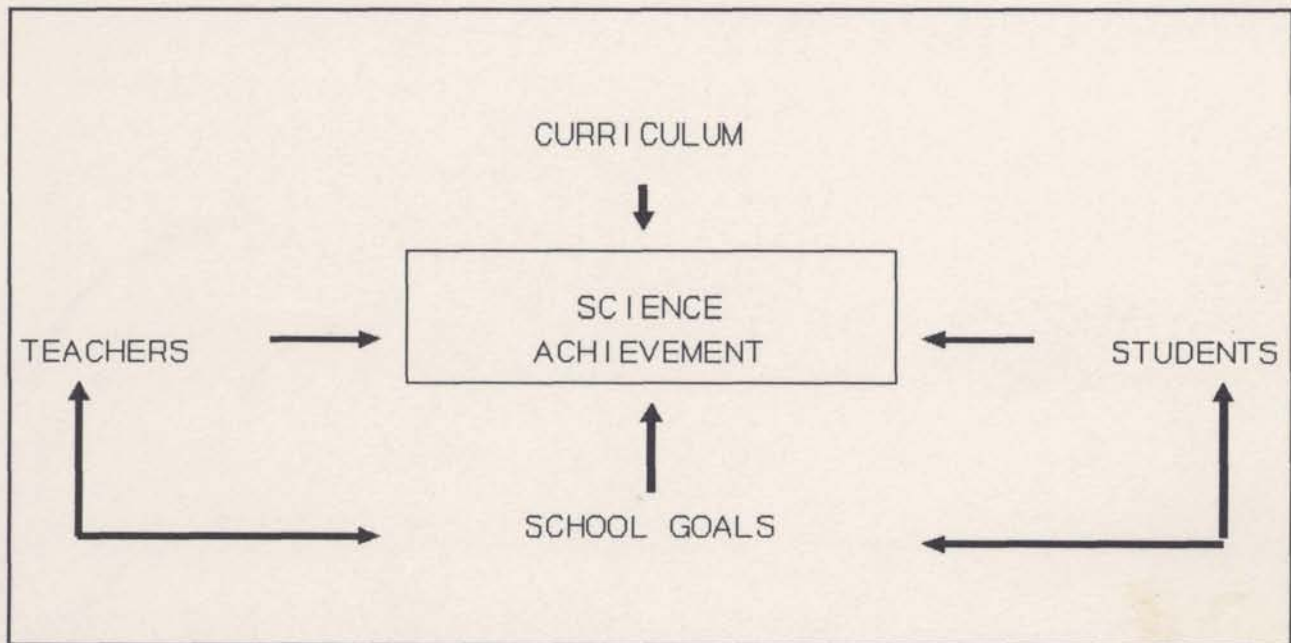
This research report describes possible causes of the declines in student science achievement between 1963 and 1990. The delineation of causes provides a framework for developing a hypothesis as to why the nationwide educational reforms of the 1980s produced only small gains in science achievement.

Since student science achievement is, to a great extent, the product of the interaction between the student, the teacher, curricula, and school goals, this research focused on changes in these four variables over the last three decades. Implications of the findings for educators and policy makers, as well as some proposed solutions to improve student science achievement are presented.

## CHAPTER 2

### RESEARCH APPROACH

The basic proposition of this research is that student achievement in science is primarily determined by four factors--the teacher, the student, the curriculum, and the school goals (Figure 1). In this research, *curriculum* is defined to be what is taught and what is intended to be learned, as well as methods of instruction, instructional technology, and teaching aids.



**Figure 1.** Determinants of Science Achievement

#### Research Premise

The premise of this research is that changes in curricula, teachers, students, or school goals must be related to the changes in student achievement after 1963. The research examines how changes in these variables could be related to the



declines in student achievement in science after 1963 and the modest recovery in student science achievement during the 1980s. By examining changes in each of these factors between 1957 and 1990, it should be possible to identify which of these four factors is most closely linked to the observed changes in student achievement in science.

If we assume, for example, that during the last 30 years all of the factors except teacher characteristics were nearly unchanged, then the changes in science achievement must be related to changes in teacher characteristics. Similarly, if all the factors were unchanged except the curricula, then the innovative curricula of this period should be associated with the changes in science achievement.

### **Research Approach**

The research approach was to (a) analyze trends in student achievement in science between 1957 and 1990; (b) describe and evaluate the curricula changes during this period; (c) describe changes in teacher and student characteristics, changes in requirements for teachers and students, and changes in school goals that relate to changes in science achievement; (d) relate changes in each of these factors to changes in student science achievement and to societal changes; (e) discuss implications of the findings for national educational reforms and for public education;

and (f) suggest some proposals that could be expected to improve science achievement.

### **Chapter Outline**

Trends in student achievement in science between 1957 and 1990 are described in Chapter 3. This chapter includes the results of the National Assessment of Educational Progress on student science achievement, as well as the results of international studies of science achievement.

Chapter 3 also describes the SAT-M trend over the last three decades. The predictive validity of the SAT-M for various groups of students in engineering and science is well documented (The College Board Technical Handbook, 1984). In a recent, yet unpublished, study by the Educational Testing Service (ETS), student achievement in a total of 810 courses in the physical sciences and biology at 35 colleges was examined. The correlation between science achievement and SAT-M score was found to be between 0.5-0.6, which makes the SAT-M as good a predictor of science achievement as the high school grade point average (J. Braswell, Educational Testing Service, personal communication, July 9, 1990).

The SAT-M was selected instead of the SAT Science Achievement Tests, because only a small percentage of the students, who take the SAT-M also take Achievement tests (18% in 1990). Furthermore the percentage of students taking individual science tests is even smaller. For example, in 1990 less than 4% of the students taking the SAT also took the Biology Achievement test. Slightly less than 3% took the Chemistry Achievement test; and less than 2% took the Physics



Achievement test (College Entrance Examination Board, 1990). A second reason for not using the Achievement tests is that the students taking these tests are not representative of the test takers as a whole. For example, in 1990 the students who took the Achievement tests had an average SAT-M of 585, nearly 100 points higher than the overall student mean.

Curricula changes in public schools since 1957 are discussed in Chapter 4. In this chapter, the major innovative curricula and instructional strategies are described and evaluated.

In chapter 5, changes in teacher and student characteristics are examined and evaluated. Chapter 6 relates changes in curricula, teachers, students, and school goals to major societal changes that have influenced public schools since 1957. The chapter also discusses the increasing involvement of the Federal Government in education, the effects of the major social movements, and some changes in the American family that have influenced public education.

The changes in science achievement, which were described in Chapter 3, are re-examined in Chapter 7 within the context of the sweeping changes in the American culture during the 1960s, 1970s, and 1980s. In this chapter, an alternative hypothesis is presented to explain the changes in science achievement. This hypothesis relates changes in science achievement since 1957 to changes in school goals and student characteristics.

Based on the analysis and discussions presented in Chapters 3 to 7, implications for schools and policy makers are presented in Chapter 8. The chapter

discusses the expected effectiveness of some of the major educational reforms based upon the findings of this research. The chapter concludes with a some proposals for raising student science achievement, as well as some conclusions about the state of public education in the United States.

### **Meta-analytical Research on Science Achievement**

The traditional method for reporting the collective results of studies in education has been narrative reviews. Narrative reviews, however, are qualitative, tend to be subjective (Light & Pillemer, 1982), and do not have systematic procedures for integrating studies and forming conclusions across studies (Cooper & Rosenthal, 1980; Light & Smith, 1971). Consequently, narrative reviews are vulnerable to reviewer bias (Slavin, 1984) and seldom are able to develop general conclusions from the studies (Hedges & Olkin, 1985).

In the last decade, meta-analysis has become a frequently used statistical method to combine the results of studies. The term meta-analysis, or analysis of analyses, was first introduced into the literature by Glass (1976), who defined it as "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings." (p. 3) Meta-analysis is a method for integrating reviews to form generalizations from a collection of studies (Bangert-Drowns, 1986).

The meta-analytic method is particularly well suited for this study because the research on the effect of the innovative science curricula and instructional methodologies is so extensive. Because so many studies have been conducted on this



topic in recent decades, the task of integrating these findings is enormous and would be beyond the capability of any individual researcher. Fortunately, during the last 15 years a number of meta-analyses have focused on these topics.

For example, the Science Meta-Analysis Project (Anderson, Kahl, Glass, & Smith, 1983) was a multi-university effort that examined broad questions concerning science education. In the same year, Wilson (1983) did a meta-analysis of the relationship between science attitude and science achievement. Becker (1989) and Lynch and Paterson (1980) used meta-analysis to investigate gender differences in pre-college science achievement. In 1985 Tamir reported a meta-analysis on cognitive preferences in learning. The results of meta-analyses such as these were used to evaluate the effectiveness of the innovative science curricula and instructional methods on student achievement in science.

### **Research Rationale**

A historical analytic approach was selected for this dissertation principally because this approach is the most appropriate technique for tracing social changes over time and for comparing these changes across cultures (Babbie, 1986; Bybee, 1982). However, there was another reason. The social sciences in general and education research in particular have been criticized for the proliferation of unrelated experimental studies that have added little to the overall theoretical body of

knowledge. This view was summarized by Hunter, Schmidt, and Jackson (1982) who said:

"At one time in the history of psychology and the social sciences, the pressing need was for more empirical studies examining the problem in question. In many areas of research, the need today is not additional empirical data but some means of making sense out of the vast amounts of data that have accumulated." (p. 26)

On the same topic, Glass, McGaw, and Smith (1981) added:

"The house of social science research is sadly dilapidated. It is strewn among the scree of a hundred journals and lies about in the unsightly rubble of a million dissertations. Even if it cannot be built into a science, the rubble ought to be sifted and culled for whatever consistency there is in it." (p. 11)

This author preferred to sift, rather than to add to the scree.

### **Research Limitations**

Historical research has certain limitations. One limitation is the inability to confirm that one factor causes another to change. In this research in particular, although certain changes can be associated with declining student science achievement, no proof of effect can be empirically established. Certainly, alternative interpretations of the data can be made, and the existence of intervening variables cannot be ruled out.

A second limitation of the study is personal values or biases that can influence selection and interpretation of historical sources (Borg, 1989; Longman, 1983). While this threat to validity applies to any type of research, it is particularly important in historical research. In this type of research, a researcher's bias may unintentionally



skew the selection and interpretation of research, tending to favor those studies that support the research. Although the author attempted to be objective, the reader is cautioned that personal biases of the author inevitably may influence both the selection and the interpretation of the data.

### **Definitions**

Certain terms have been defined for use in this research. These terms are:

*Curriculum:* what is taught and what is intended to be learned, as well as methods of instruction, instructional technology, and teaching aids.

*Involvement:* federal legislation, court rulings, funding restrictions, and administrative guidelines pertaining to public education.

*School goals:* the long-range, school outcomes as determined by the school district (Posner & Rudnitsky, 1986; Zais, 1976). School goals are the guiding principles, which help to set the tone for the classroom learning climate.

*Societal factors:* federal and state involvement in public education, societal movements, and changes the American family and community that altered school goals in public schools.

## CHAPTER 3

### TRENDS IN SCIENCE ACHIEVEMENT

The 1985 report, *High School and Beyond: A National Longitudinal Study for the 1980s* (West, Miller, & Diodato, 1985), opened:

Over the last 20 years, the United States has witnessed a widespread decline in the quality of education. This decline has been especially pronounced with respect to mathematics and science, as evidenced by lowered enrollments and achievement scores, a diminishing teacher pool, and increased numbers of students on a general education track. (p. xiii)

The state of science education in public schools had been summarized previously in *A Nation at Risk* (1983), which reported that the "average achievement of high school students on most standardized tests was lower in 1983 than in 1957 when Sputnik was launched." Thus, the science dilemma was twofold: students in the United States were lacking both in aptitude and interest in science.

The declines in science achievement resulted in widespread education reforms in the 1980s. However, as this chapter shows, the reforms did not produce the expected gains in science achievement scores. According to the National Science Board (1989), "National and international indicators of U.S. school mathematics and science performance show little improvement, despite continuing major reform efforts." (p. 2) The Board reported that fewer college freshmen were selecting majors in science or engineering and that the rate of increase of enrollment in



graduate science or engineering programs was slowing. At the same time, the percentage of foreign students receiving Ph.D.s in science and engineering at American universities continued to increase, while the percentage of native United States students decreased.

In this chapter, trends in science achievement are documented by examining the results of national assessments of science achievement and international tests of science achievement, as well as trends in the SAT-M.

### **National Tests of Science Achievement**

The National Assessment for Educational Progress (NAEP) measured the science achievement of 13- and 17-year-old American students in 1970, 1973, 1977, 1982, and 1986. These results for 13-year-olds and 17-year-olds are shown respectively in Tables 1 and 2.

As shown in Table 1, the overall student science scores for 13-year-olds declined by 7 points between 1970 and 1977. The scores then increased from a low point of 247 in 1977, reaching 251 in 1986. Despite these modest gains, the 1986 scores for 13-year-olds were still lower than in 1970. These trends are shown in Figure 2. As the figure shows, males consistently outscored females on the test. This phenomenon was consistent with trends found on the SAT-M (Figure 12).

TABLE 1

NAEP ASSESSMENT OF SCIENCE PROFICIENCY FOR 13-YEAR-OLDS:  
1970-1986

STUDENT CHARACTERISTICS	YEAR				
	1970	1973	1977	1982	1986
All Students	254.9	249.5	247.4	250.2	251.4
Male	256.8	251.7	251.1	255.7	256.1
Female	253.0	247.1	243.8	245.0	246.9
White	263.4	258.6	256.1	257.3	259.2
Black	214.9	205.3	208.1	217.2	221.6
Hispanic	-----	-----	213.4	225.5	226.1
Source: Mullis & Jenkins, (1988)					

TABLE 2

NAEP ASSESSMENT OF SCIENCE PROFICIENCY FOR 17-YEAR-OLDS:  
1970-1986

STUDENT CHARACTERISTICS	YEAR				
	1970	1973	1977	1982	1986
All Students	304.8	295.6	289.6	283.3	288.5
Male	313.8	304.3	297.1	291.9	294.9
Female	296.7	288.3	282.3	275.2	282.3
White	311.8	303.9	297.7	293.2	297.5
Black	257.8	250.4	240.3	234.8	252.8
Hispanic	-----	-----	262.3	248.7	259.3
Source: Mullis & Jenkins, (1988)					



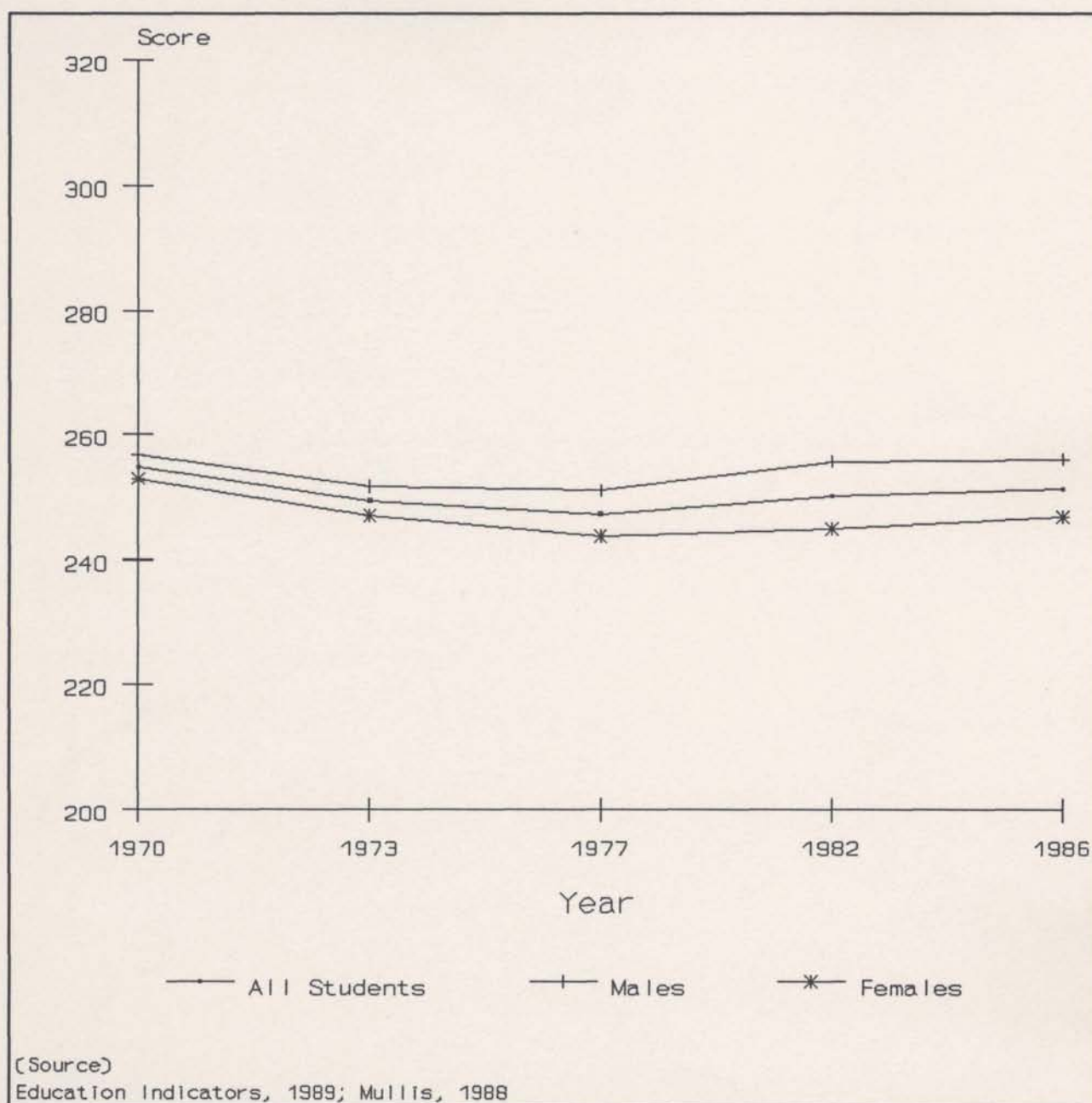


Figure 2. NAEP Scores for 13-Year-Olds (By Gender)

The trend was similar for 17-year-olds, including the gap between male and female scores (Figure 3). In this age group, achievement scores declined by 21 points between 1970 and 1982 (Table 2). The scores then increased in 1986, but like the

scores for the 13-year-olds, the gains for 17-year-olds did not offset the previous declines, so that the 1986 student scores were still 16 points lower than in 1970.

When the achievement scores were broken down by racial group (Figure 4 and Figure 5), several interesting differences became apparent. Between 1970 and 1986, the achievement scores of 13-year-old White students declined by 4 points. The decline was much more severe for 17-year-old White students, dropping 14 points. In contrast, achievement scores for 13-year-old Black students rose nearly 7 points between 1970 and 1986. For 17-year-old Black students, scores declined, but only by 5 points during the same period. The trends indicate that the test score declines were greater for White students than for Black students.

The different trends for Black students in comparison to White students were even more apparent between 1977 and 1986--the eras of the "Back-to-Basics" and "Excellence" educational reforms. (The "Excellence" reforms [1983-] were in response to the report, *A Nation at Risk*, 1983). During this time, achievement scores for 13-year-old Black students rose nearly 14 points; for 17-year-old Black students by nearly 18 points. In comparison, achievement scores for 13-year-old White students rose only 3 points during the same period, while scores for 17-year-olds remained nearly unchanged. It would appear that the educational reforms during the 1970s and 1980s may have been more beneficial for Black students than for White students.

The trends for 13-year-old Hispanic students were similar to the trends for 13-year-old Black students, with achievement scores for 13-year-old Hispanic students increasing by nearly 13 points between 1977 and 1986. However, gains made by 13-



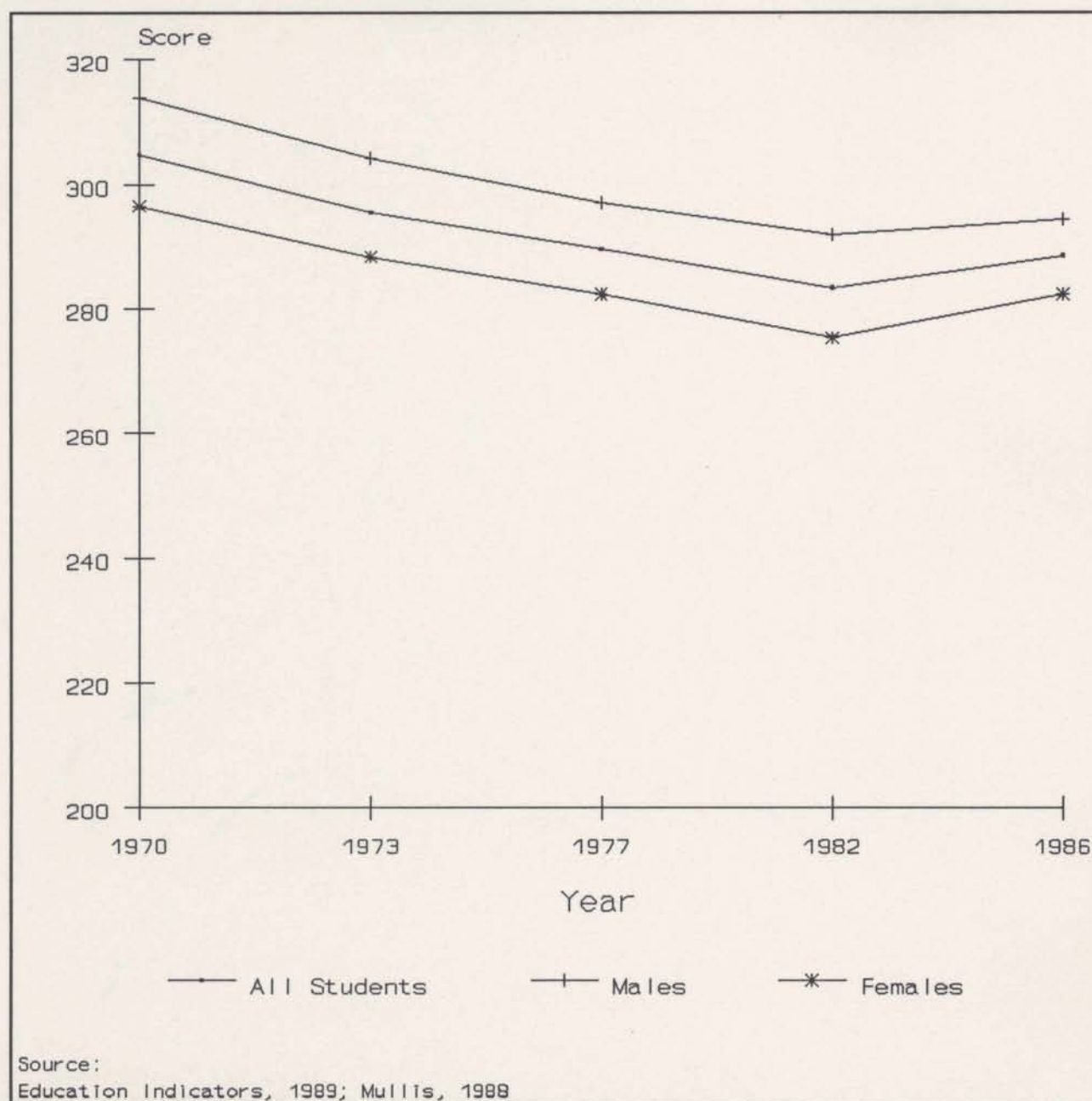


Figure 3. NAEP Scores for 17-Year-Olds (By Gender)

years-olds were not shared by 17-year-old Hispanic students. During this same nine-year period, achievement scores for 17-year-old Hispanic students fell 3 points.

From this data, it would appear that the "Back-to-Basics" and "Excellence" educational reforms benefitted both 13-year-old Black and Hispanic students, as well

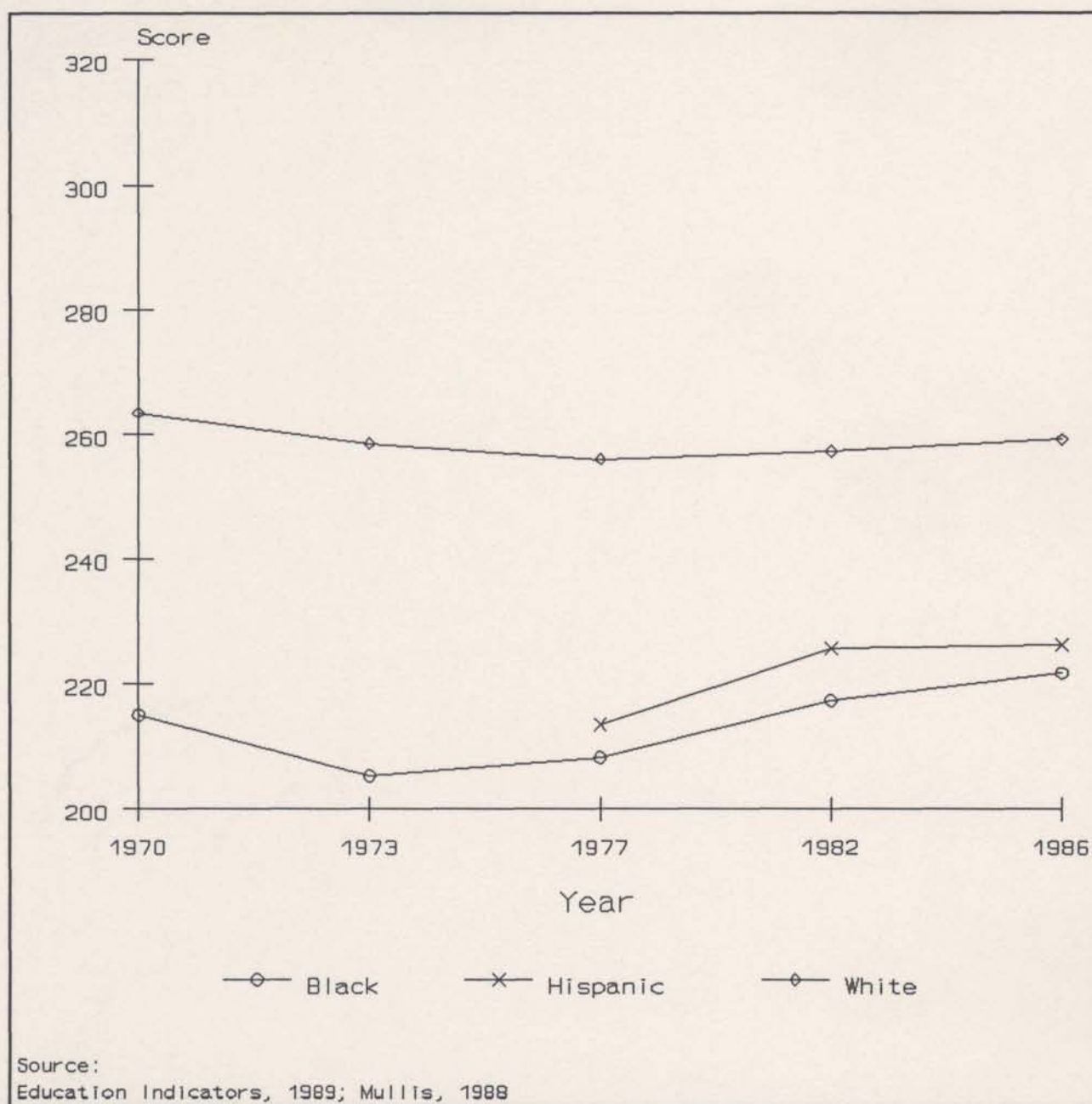


Figure 4. NAEP Scores for 13-Year-Olds (By Race/Ethnicity)

as 17-year old Black students. For 17-year-old White and Hispanic students, 9 years of educational reforms did not seem to produce any gain in science achievement.

Although the overall achievement scores improved somewhat in 1986, the specific areas of improvement were cause for further concern. The NAEP test



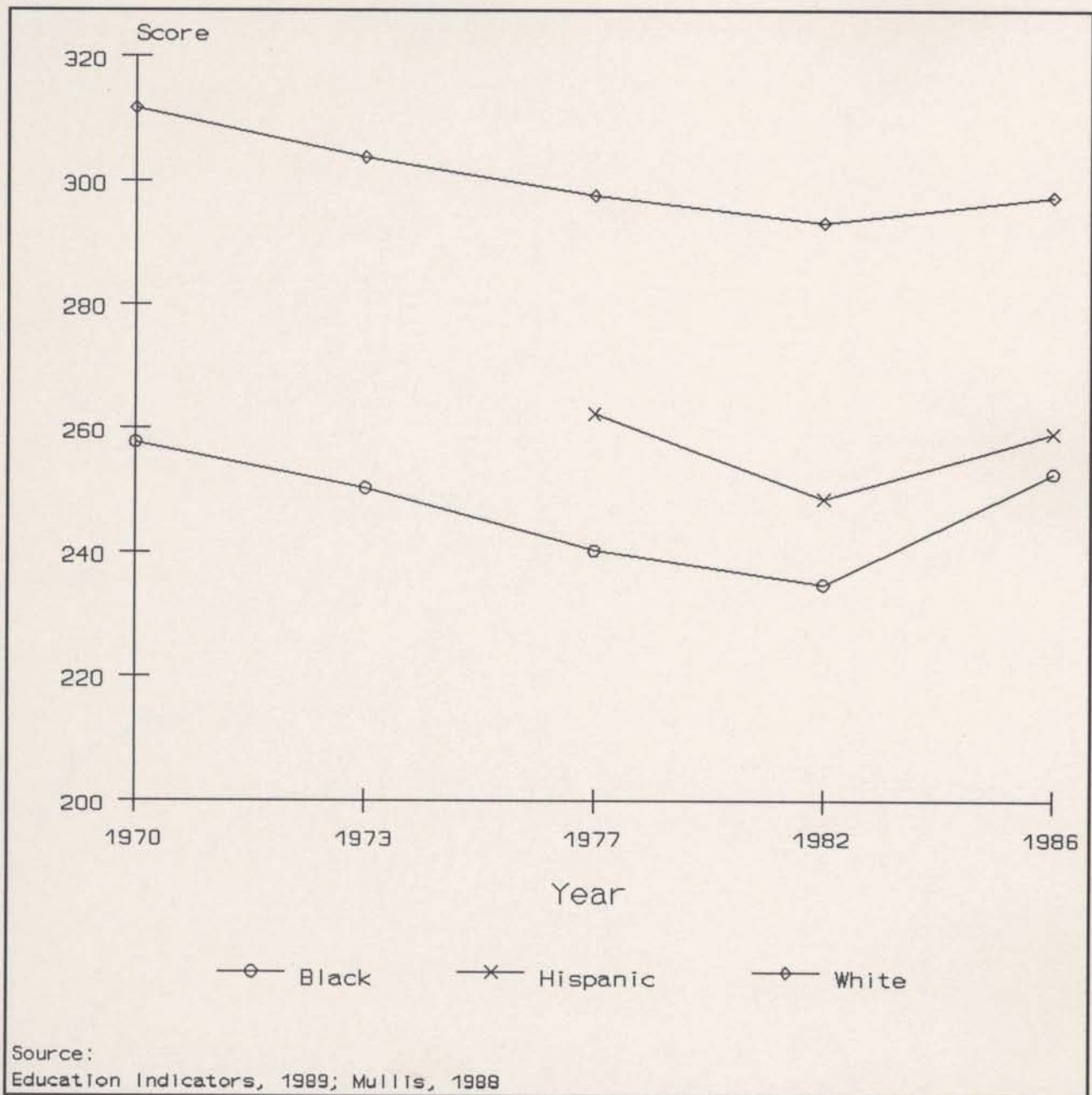


Figure 5. NAEP Scores for 17-Year-Olds (By Race/Ethnicity)

evaluates five levels of student learning. In ascending order of difficulty, the levels are factual knowledge, understanding, application, analysis, and integration of

scientific principles and information. Table 3 shows the percentage of students able to perform at each of these five levels.

The 1986 overall score gains caused further concern on the part of the education community because the improvement occurred in the lower skill categories. Both 13-year-old and 17-year-old students were less able to analyze and to integrate scientific information in 1986 than in 1977. Furthermore, 17-year-old students were less able to understand and to apply scientific principles in 1986 compared to 1977. As Table 3 shows, achievement scores for 17-year-olds were lower for all the higher skill levels in 1986 than in 1977. The results for 13-year-olds were slightly more encouraging. In addition to showing improvement in basic scientific knowledge, 13-year-olds showed gains in level 200 and level 250 skills.

Nevertheless, despite a decade of educational reforms that specifically emphasized higher order thinking skills, such as the analysis and integration of information and the development of critical thinking skills, student scores in higher level thinking skills were lower in 1986 than in 1977 for both age groups. In the 1986 NAEP test, only 7.5% of the 17-year-old students were able to "integrate specialized science information, infer relationships, and draw conclusions using knowledge from the physical sciences and applying principles of genetics." (*Education Indicators*, 1989).



TABLE 3

PERCENTAGE OF 13- and 17-YEAR-OLD STUDENTS AT OR ABOVE THE  
FIVE SCIENCE LEVELS

SKILL LEVEL	AGE	YEAR		
		1977	1982	1982
		PERCENTAGE		
Level 150 Knows everyday science facts	13	98.6	99.6	99.8
	17	99.8	99.7	99.9
Level 200 Understands simple scientific principles	13	85.9	89.6	91.8
	17	97.2	95.8	96.7
Level 250 Apply basic scientific information	13	49.2	51.5	53.4
	17	81.8	76.8	80.8
Level 300 Analyze scientific procedures and data	13	10.9	9.4	9.4
	17	41.7	37.5	41.4
Level 350 Integrates specialized scientific information	13	0.7	0.4	0.2
	17	8.5	7.2	7.5
Source: Mullis & Jenkins, (1988)				

### International Tests of Science Achievement

The declines in student science achievement were not confined to the National Assessments of Educational Progress. Two international tests of science achievement were conducted in 1986 and 1988. The first assessment was *Science Achievement in Seventeen Countries*, conducted by the International Association for the Evaluation of Educational Achievement (IEA). This science assessment tested students in grades 4 or 5 (age 10), grades 8 or 9 (age 14), and grade 12 (if enrolled in science).

The second assessment was *The International Assessment of Educational Progress* (IAEP), conducted by the Educational Testing Service. The IAEP tested 13-year-olds in six countries.

#### Science Achievement in Seventeen Countries

In this study, 14-year-old United States students were outscored by students in Hungary, Japan, Netherlands, Canada, Finland, Sweden, South Korea, Poland, Norway, Australia, England, and Italy (Figure 6). The students in the United States were tied with students in Singapore and Thailand. Only students in Hong Kong and the Philippines scored lower than students in the United States.

Achievement scores were also determined for grade 12 students who were taking biology, chemistry, or physics. In these tests, students in Hong Kong and the United Kingdom scored the highest. Students in the United States ranked last in



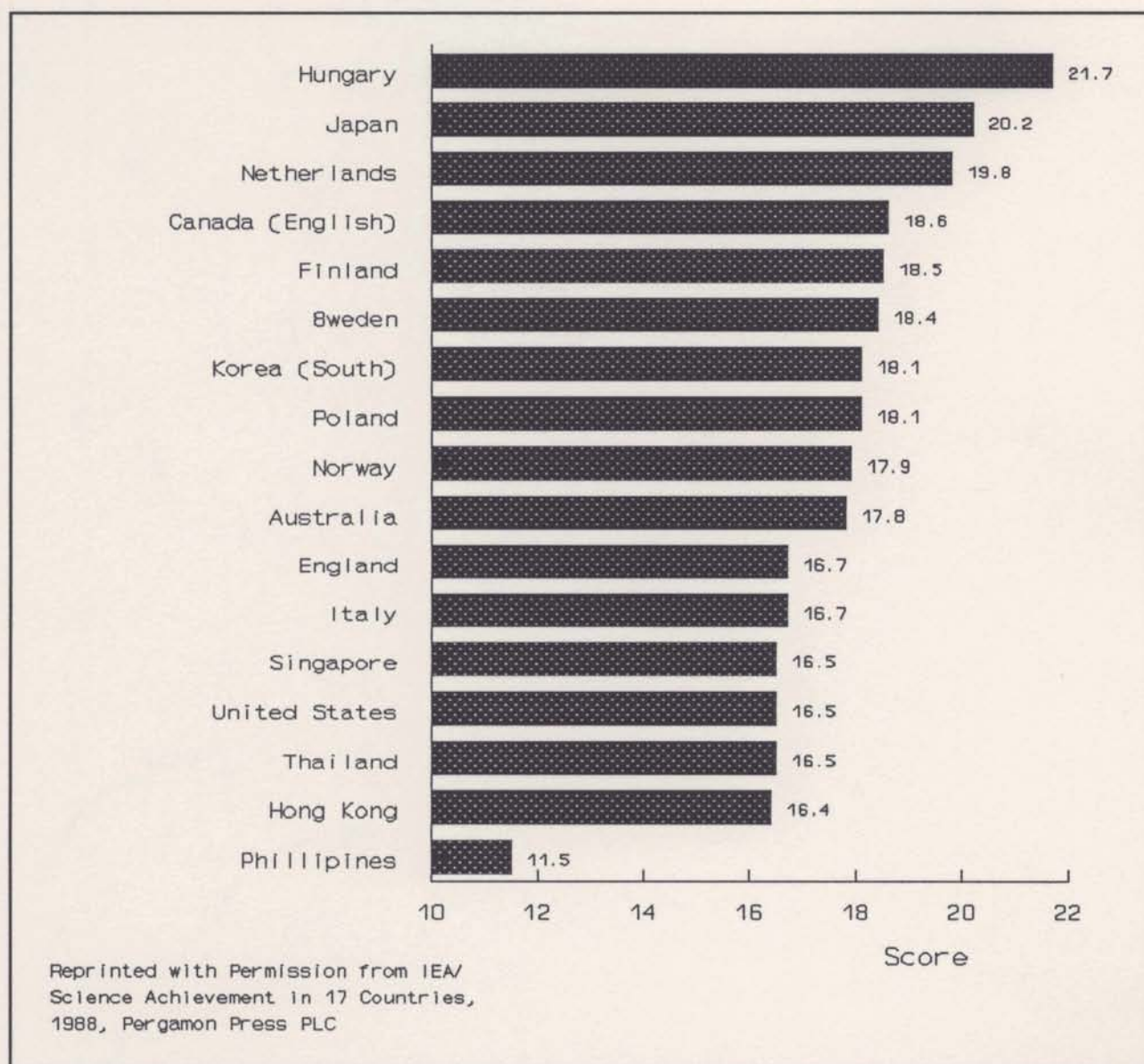


Figure 6. 1983-86 Science Test Scores for 14-Year-Olds In Selected Countries

biology, ahead only of Canada and Finland in chemistry, and fifth from last in physics (Figures 7, 8, and 9).

### International Assessment of Educational Progress (IAEP)

In 1988, the IAEP conducted science and mathematics assessments in five countries and 4 Canadian provinces. The project evaluated 13-year-old students in

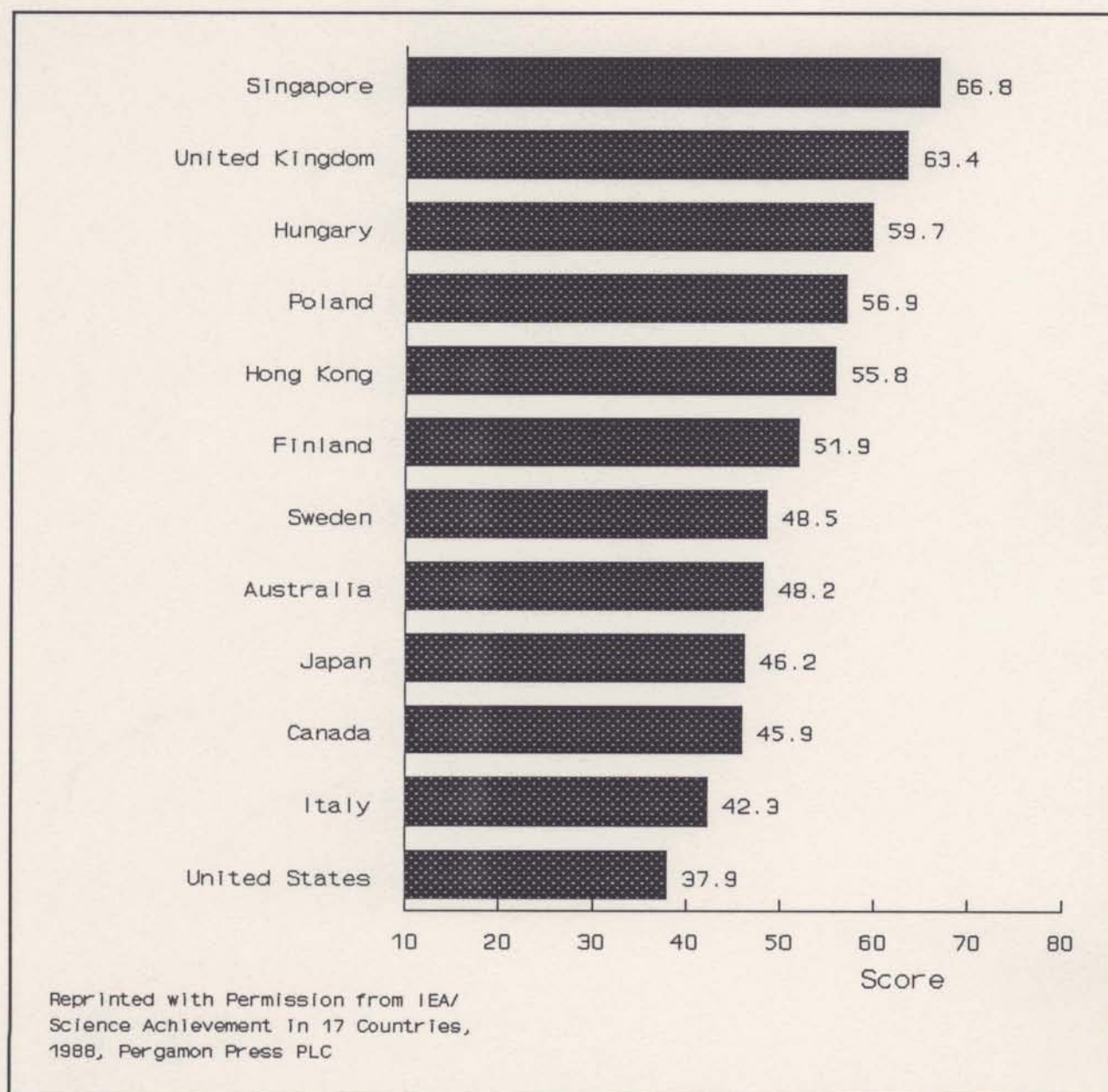


Figure 7. 1988 IEA Biology Assessment

the United States, Canada, Korea, the United Kingdom, Spain, and Ireland. In each country and province, students were randomly selected. A total of 24,000 students were tested. The 45-minute test consisted of 63 questions in mathematics and 60 questions in science. The questions were selected from the 1986 NAEP assessment.



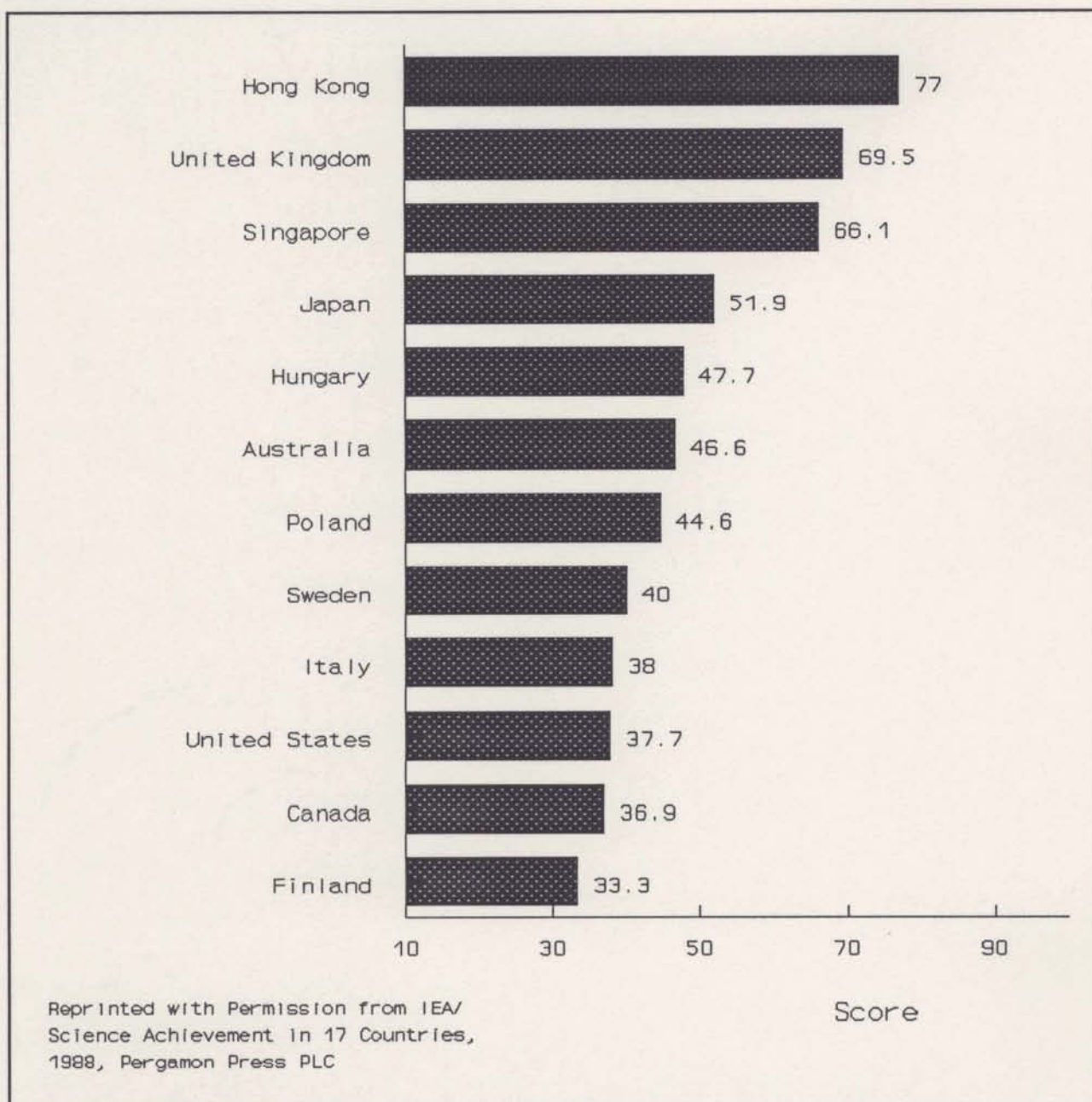


Figure 8. 1988 IEA Chemistry Assessment

The scoring scale ranged from 0 to 1000 with a mean of 500 and a standard deviation of 100. The results of this international assessment are shown in Figure 10.

According to IAEP tests, students in the United States were outscored by students in Korea, the United Kingdom, Canada, and Spain. Only students in Ireland

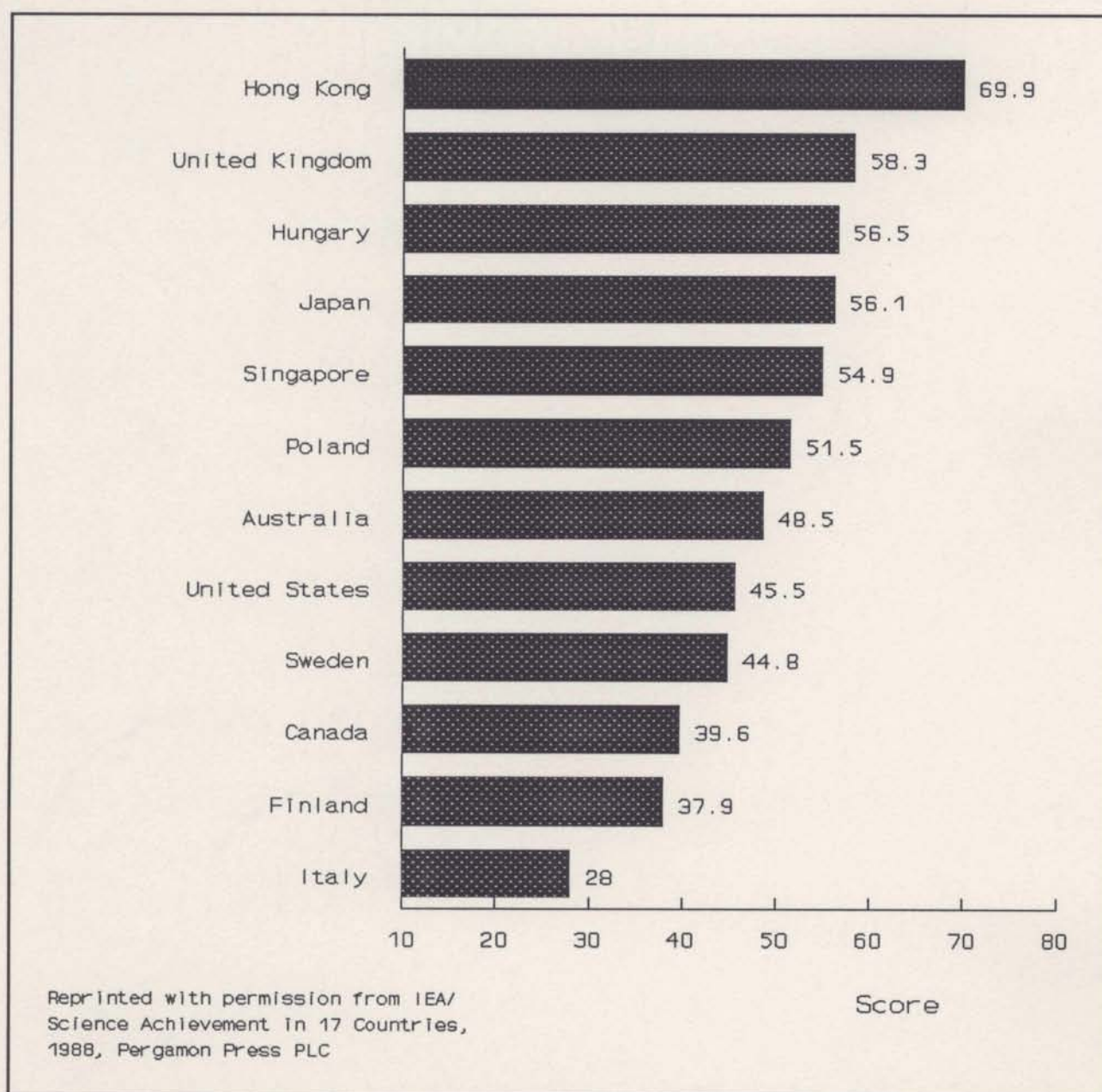


Figure 9. 1988 IEA Physics Assessment

scored lower than students in the United States in science proficiency.

Some of the highlights of the findings were that 72% of the 13-year-old students in British Columbia and 73% of Korean students could analyze experiments, compared to only 42% of American students. Similarly, 31% of students in British



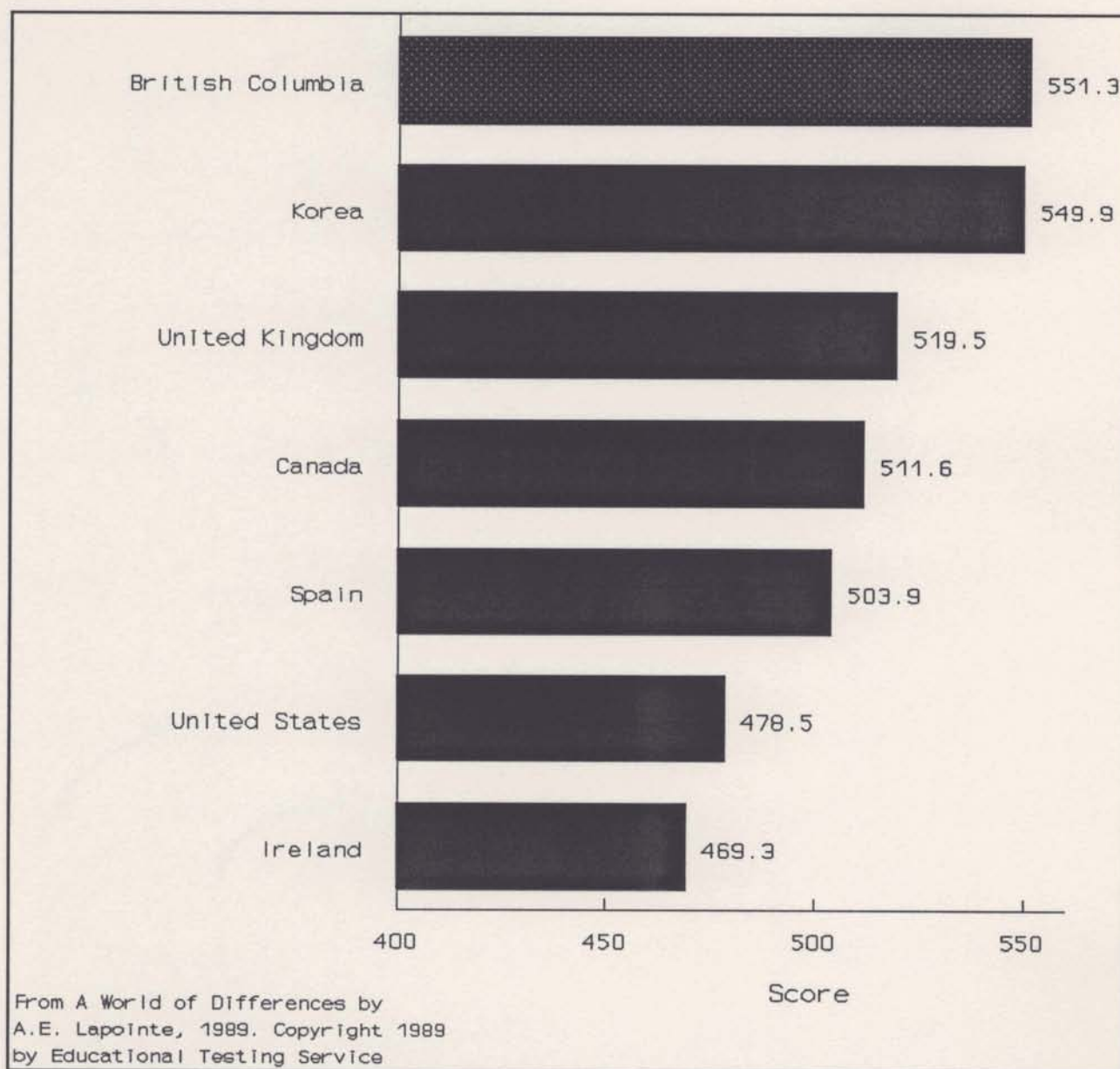


Figure 10. 1988 Science Proficiency at Age 13 In Selected Countries

Columbia and 33% of Korean students were able to apply intermediate scientific principles, but only 12% of students in the United States had this capability. The IAEP test results were consistent with the NAEP findings. Both tests indicated that student science achievement in the United States had worsened since the 1960s.

### Scholastic Aptitude Mathematics Test (SAT-M)

The SAT-M is strongly correlated with college achievement in science and engineering. J. Braswell (personal communication, April 3, 1990), a senior examiner at the Educational Testing Service reported the results of a yet to be published study of 810 physics and biology courses in 35 colleges. The study found that the correlation between the SAT-M average and success in the science courses was between 0.5-0.6, which is equal to the predictive validity of the high school record as a predictor of success in science.

An advantage in including the SAT-M in the analysis of science achievement trends is that this test is administered annually to a large segment of college bound students. Therefore, the SAT-M provides a more detailed and extensive picture of trends in student science achievement than the national and international science assessments.

There are two important cautions that must be considered in interpreting the trends in the overall (aggregate) SAT-M scores<sup>1</sup> (College Entrance Examination Board, 1990). First, the aggregate SAT-M scores are influenced by gender, racial/ethnic background, socio-economic status, and educational preparation. Therefore, changes in aggregate SAT-M scores over time can be related to changes in any of these factors--not just to changes in educational preparation. Also, it must

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<sup>1</sup>Aggregated scores are scores not broken down by gender, racial/ethnic background, or socio-economic status.



be remembered that the relationship between some of these factors may only be associational--not necessarily causal.

The second limitation on interpreting trends is that the subjects for the SAT-M are "self-selected" and not a random sample high school student population. From state to state, and to a lesser extent from year to year, the percentage of students taking the SAT-M varies. According to the College Entrance Examination Board (1990), the percentage of minority students taking the SATs has steadily increased from 11% in 1973 to 27% in 1990, while the percentage of White students taking the test has declined from 87% in 1973 to 73% in 1990. In 1990, the SAT test-taking population was 73% White, 10% Black, 8% Asian-American, 6% Hispanic, 2% other and 1% American Indian (College Entrance Examination Board, 1990).

Since 1976 the College Board has broken down test scores according to demographics. By examining trends of various racial groups, "useful comparisons over time can be made among subgroups of the test-taking population" (College Entrance Examination Board, 1990).

The scoring trends in SAT-M have nearly paralleled the trends in the national and international tests of student science achievement. The trends in student performance on the SAT-M are shown in Figure 11. A listing of average SAT-M scores, both aggregate and broken down by gender and racial or ethnic group, are contained in Appendix A.

Keeping the caveats in mind, let us now examine the SAT-M trends. Between 1952 and 1963, the SAT-M scores rose from 494 to 502. During the following 18

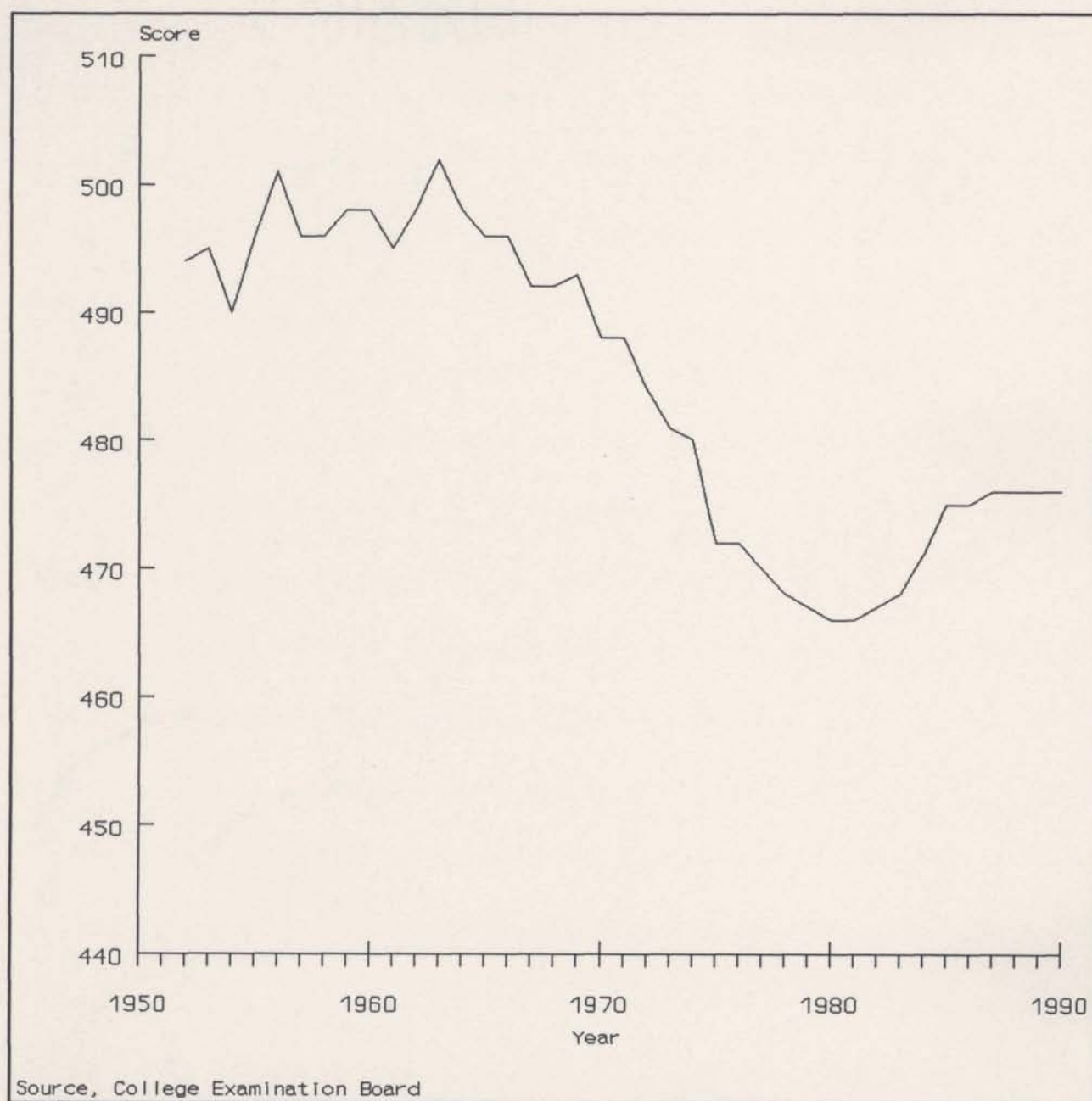


Figure 11. Aggregate SAT-M Scores: 1952-1990

years, the scores followed a nearly unbroken pattern of decline, reaching a low point of 466 in 1981, with average SAT-M scores dropping nearly 40 points. The sharpest drop in scores occurred between 1971 and 1975, when the SAT-M scores fell 10 points. From 1981 to 1985 the SAT-M scores climbed steadily from 466 to 475.



However, since 1985, the curve has been nearly flat with SAT-M scores increasing by only one point. As the figure shows, the recovery during the 1980s was not sufficient to erase the earlier declines. In 1990 the aggregate SAT-M score of 476 was still 26 points lower than in 1963. The 1990 aggregate score was 12 points lower than in 1970.

Since 1967, when SAT-M scores were first broken down by gender, the scores for males and females have exhibited the same general trend (Figure 12). The absolute difference between male and female scores tended to remain nearly constant. In addition both male and female scores followed a general pattern of decline from 1966 to 1979. Between 1981 and 1990 female scores generally improved. Scores for males, however, peaked in 1986. Between 1986 and 1990, scores for males were generally unchanged.

The SAT-M trends for different racial/ethnic groups (Figure 13) were markedly different from the aggregate score trend (Figure 11). As the table shows, scores for Asian students rose since 1981, reaching 528 in 1990. The Asian students are the only racial/ethnic group of students who have exceeded the overall 1963 SAT-M scores.

SAT-M scores for White students declined between 1976 and 1979, and then increased between 1980 and 1987. However, the recovery was not sufficient to reach the 1976 level. SAT-M scores for White students in 1990 were still 2 points lower than in 1976.

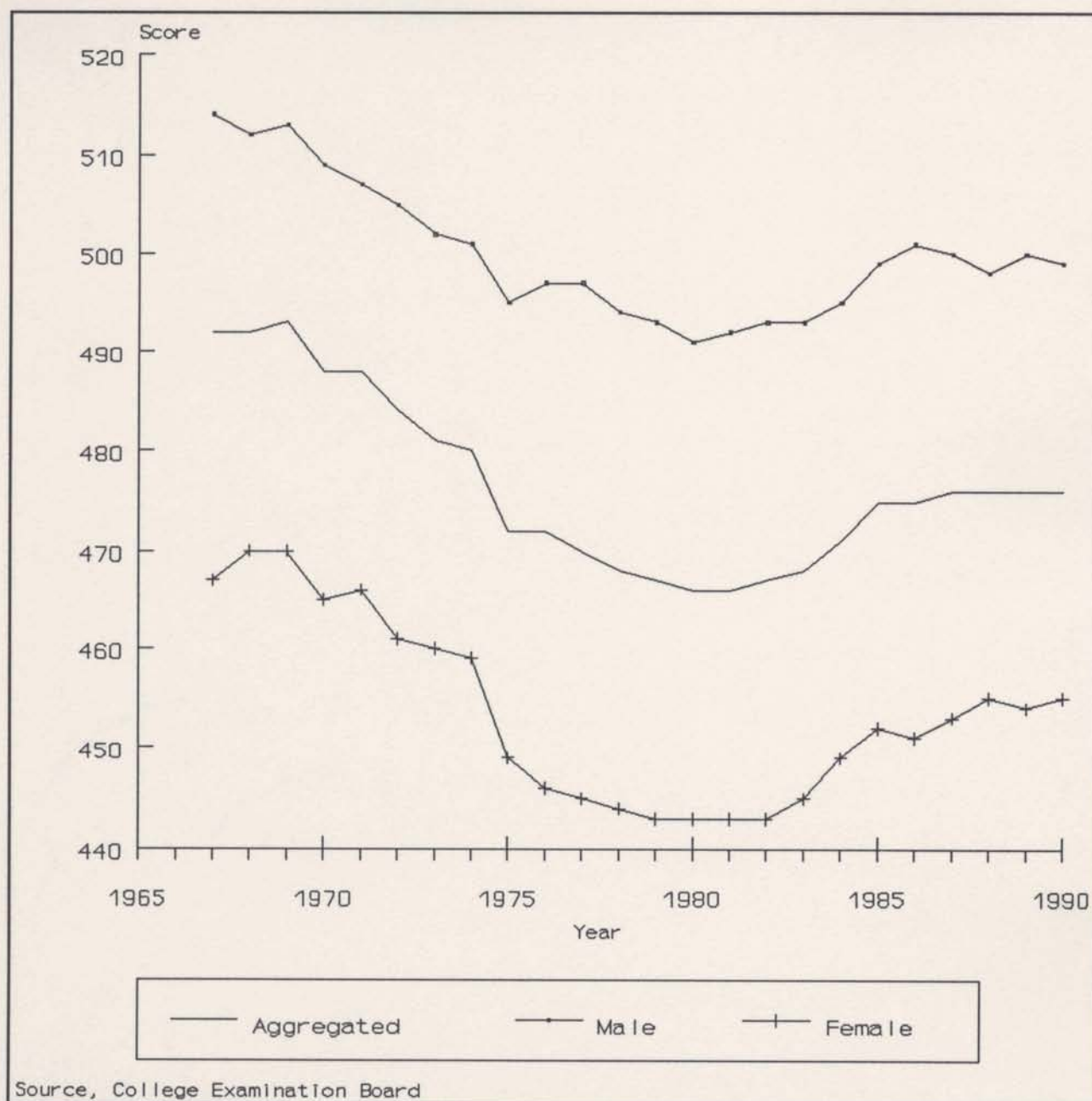


Figure 12. SAT-M Scores Broken Down by Gender

In sharp contrast, the scores of Black students rose steadily from 1976 to 1990. The 31-point gain by Black students far exceeded that of any other groups. Even though the achievement levels for Black students were still significantly lower than



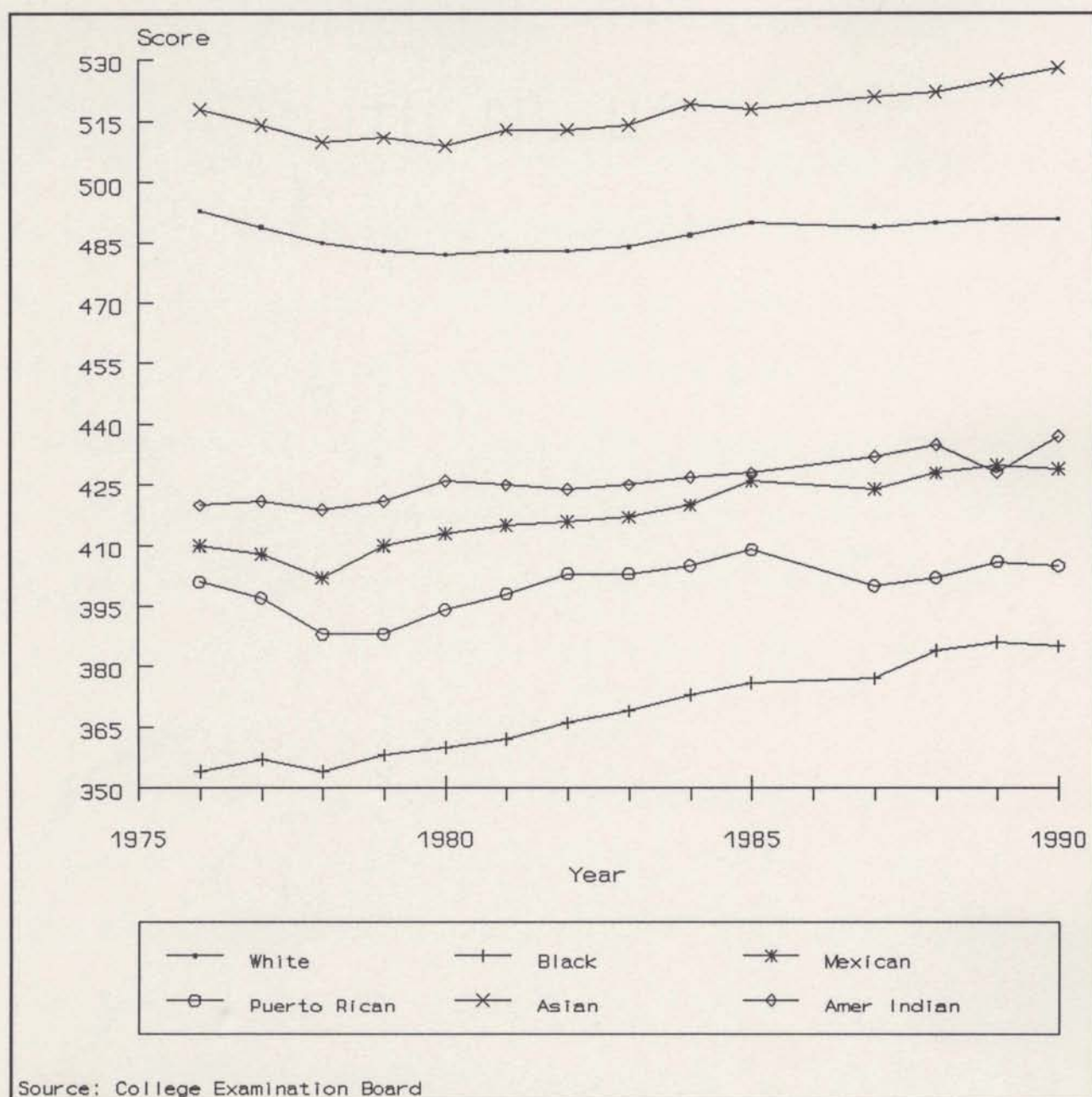


Figure 13. SAT-M Scores Broken Down by Race/Ethnicity

for other student groups (Figure 13). The SAT-M average for Hispanic students declined between 1976 and 1978, and then increased from 1980 to 1985. The scores

for Hispanic students declined sharply in 1987 but recovered somewhat, reaching a level of 405 in 1990, which was the same as in 1984.

The scores for American-Indian students exhibited a plateau effect. Between 1976 and 1979, their SAT-M scores remained relatively constant at about 420. The scores then increased to 426 in 1980 and remained at about this level until 1985. In 1987 the scores rose to 432. In 1990 the SAT-M scores for American Indians reached their highest level--437. This score was 17 points higher than in 1976. The overall scoring trend for Indian students was similar to the trends for Asian-American, Mexican-American, Puerto Rican, and Black students. For each of these groups, their average score was higher in 1990 than in 1976. Only the scores of White students were lower in 1990 than in 1976.

Table 4 lists the correlations between the 1976 and 1989 SAT-M scores. As the table shows, the correlations were statistically significant for all minority students, but not for White students. This result indicates that the achievement trend for White students was not similar to the other groups.

If the cause of declining SAT-M scores was due to a lessening in the quality of teachers, science and mathematics curricula, methods of instruction, and requirements for teachers and students, then all student groups should have been similarly affected. Therefore, the achievement scores of males and females and racial groups should have exhibited the same trends.

One possible interpretation of these group differences is that 1) changes in teachers, curricula, or other school factors influenced science achievement in very



different ways for the different ethnic/racial groups. A second interpretation could be that the various student characteristics evolved differently for various racial and ethnic groups so that students in different groups reacted differently to changes in the learning climate. This second interpretation is explored more fully in Chapter 5.

TABLE 4  
SAT-M TREND ANALYSIS BY RACE: 1976-1989

RACE/ETHNICITY	PEARSON R	DF	SIGNIFICANCE
Asian-American	.568	11	.05
Black	.990	11	.01
Indian-American	.897	11	.01
Mexican-American	.950	11	.01
Puerto Rican	.623	11	.05
White	.271	11	not signif.
Source: <i>Digest of Education Statistics</i> , 1989; Dodge, 1989, September			

The significance and extent of the decline in SAT-M scores were underscored by the 1977 College Entrance Examination Board report *On Further Examination*. To understand more clearly the nature of the decline in SAT-M scores, the authors of this report commissioned 28 separate studies dealing with declining SAT scores. The authors even considered the possibility that the declines might be due to bias caused by changes in the test itself. To investigate this possibility, 3174 high school students from 66 schools were given both the 1963 and the 1973 SAT editions. The researchers found that the students scored on average 8 to 12 points lower on the

1963 SAT. Based on these results, the authors concluded that "the standard established in this test has remained substantially constant, and the decline the scores reflect is, if anything, slightly larger than the reported record indicates." (p. 10)

### **Conclusions**

The decline in science achievement in the last 30 years is real and it is substantial. The Advisory Panel on the Scholastic Aptitude Test Score Decline (1977) recognized the seriousness of the decline in test scores when it reported:

Our assessment of this continuous 14-year drop in averages [SAT] is that it is unquestionably significant. Particularly when the SAT record is set beside the broader pattern of comparable declines on the other standardized academic tests, it emerges as a development warranting careful attention by educators and by everybody interested in education. (p. 45)

The declines in science achievement were mirrored in the National Assessments of Educational Progress scores, in the SAT-M trends, and in the international science comparison studies. There is no question that science achievement in the United States peaked around 1963, followed by a steady decline in achievement for nearly two decades (1963-1981).

By 1990 following a decade of comprehensive, national educational reforms, the weakness of the gains in science achievement questioned the efficacy of these reforms. Education Secretary Lauro F. Cavazos reflected, "Today's college bound students are still scoring significantly below those of 20 years ago. This is especially



disheartening at the end of a decade marked by substantial education reform efforts" (Dodge, 1989). (p. 8)

The results of the 1988 International Assessment of Educational Progress showed that students in the United States placed near the bottom. Only 42% of American students could use scientific procedures and could analyze scientific data, compared to 72% of British Columbian students and 73% of Korean students. Less than 10% of American students could apply intermediate scientific knowledge and principles in designing experiments and interpreting data, compared to 33% of Korean students (Lapointe, Mead, & Phillips, 1989).

The seriousness of the declines in student achievement in science were recognized in the 1989 edition of *Science Indicators*, which noted that:

Despite recent improvements with respect to some age and ethnic racial groups, both participation and achievement by U.S. elementary and secondary students in science and mathematics are lagging behind previous years and other countries. Compared with students in other developed countries, American students demonstrate lower achievement in problem solving and higher-order thinking. (p. 21)

The research is substantial and conclusive. Student achievement in science peaked in the early 1960s. The declines that followed are genuine and the weakness of the recovery during the 1980s is a fact. The seriousness of the declines in science achievement were further highlighted by the poor performance of American students on the international tests of science achievement.

Now that it has been established that the science achievement of students in the United States has declined, the next two chapters investigate what changes in curricula, teachers, students, or school goals could account for these declines. The

purpose of these chapters is to try to identify which of these variables could be linked to nearly two decades of declines in student achievement, and to the inability of the recent widespread, comprehensive educational reforms to have a stronger positive effect on student science achievement.



## CHAPTER 4

### CURRICULA

Curricula, as defined in this research, encompass the course of study, both the content and the methods of instruction. Curricula also include the use of instructional aids such as computer technology and other educational support equipment. In this chapter, changes in curricula during the 1960s, 1970s, and 1980s are reviewed and the effects of these changes on student achievement are evaluated.

#### Background

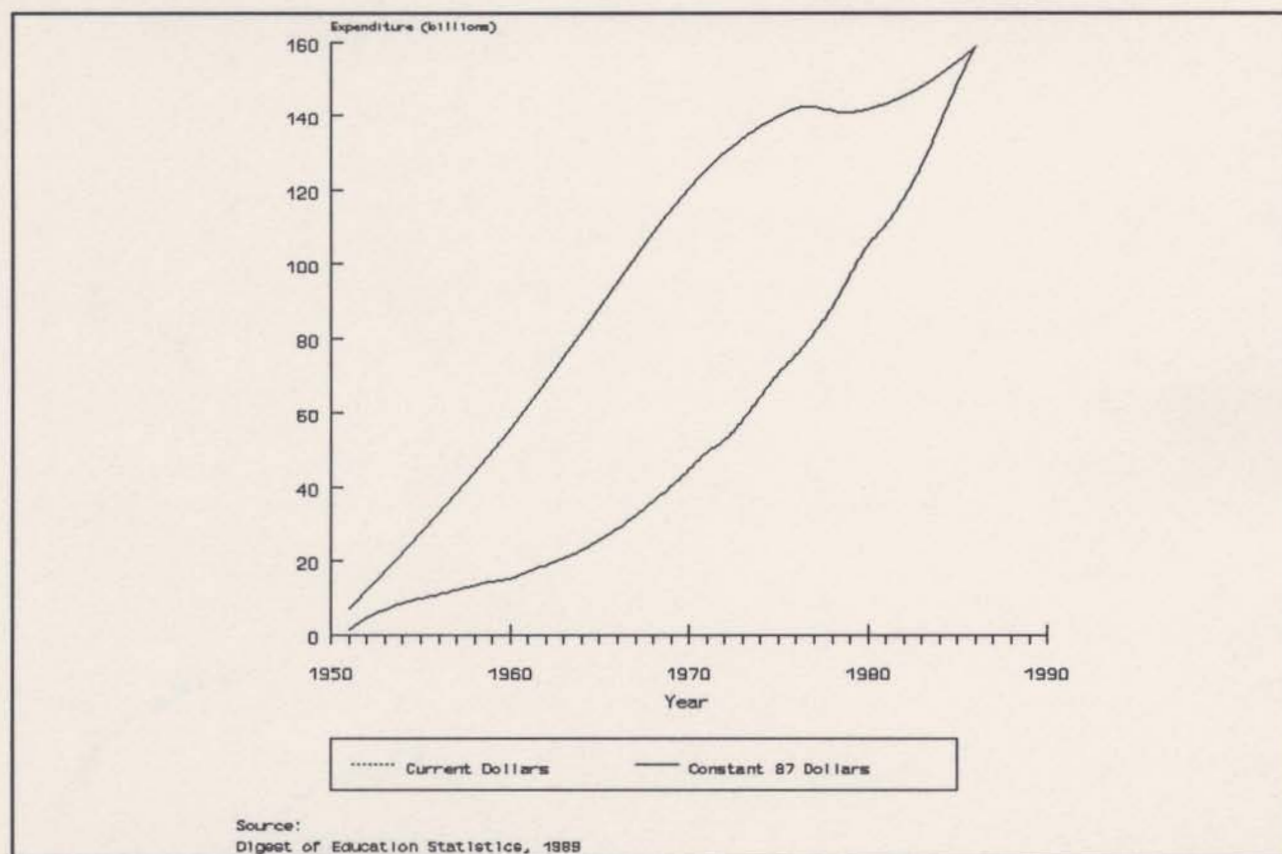
Local, state, and federal funding for public education had begun to increase in 1950, increasing from 32.7 billion dollars in 1950 to 51 billion in 1960<sup>1</sup>. However it was beginning in 1958 that funding for public education appeared to explode, following the Soviet Union's success in orbiting Sputnik, the first Earth satellite. As Figure 14 shows, between 1960 and 1987 funding for public education increased by more than 300% in constant 1988 dollars, reaching 158.8 billion dollars by 1987 (*Education Indicators*, 1989).

In terms of per pupil expenditures, the funding increases during this period were equally dramatic. Referring to Table 5, total per pupil expenditures expressed

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<sup>1</sup>Funding levels are given in constant 1988 dollars.

in constant 1987-1988 dollars increased from \$1735 in 1959 to \$4370 in 1988. This



**Figure 14.** Public Elementary and Secondary Public School Expenditures

per-pupil spending level for elementary and secondary education in the United States is much higher than the Japanese spend on their students (Dentzer, 1990).

Although educational quality cannot be directly correlated to funding levels (Childs and Shakeshaft; 1986), the funding increases after Sputnik made possible the development of the innovative science curricula. These funding increases also were used to improve science laboratories and to develop learning aids. The funding was



also used to provide workshops and other training vehicles to improve the skills and knowledge of science teachers.

TABLE 5  
PER PUPIL EXPENDITURES IN PUBLIC ELEMENTARY AND  
SECONDARY SCHOOLS: 1951-1988

EXPENDITURES PER PUPIL IN FALL ENROLLMENT (CONSTANT 1987-1988 DOLLARS)		
SCHOOL YEAR	TOTAL EXPENDITURES <sup>2</sup>	INSTRUCTIONAL EXPENDITURES
1951-1952	1214	949
1955-1956	1525	1159
1959-1960	1735	1382
1961-1962	1870	1515
1965-1966	2204	1812
1969-1970	2692	2300
1971-1972	2911	2555
1975-1976	3267	2894
1979-1980	3417	3117
1981-1982	3413	3104
1985-1986	4004	3696
1988-1989	4370	3987
Source: <i>Digest of Education Statistics</i> (1989)		

<sup>2</sup>Total expenditures include instructional expenditures; capital outlay; and interest on school debt, summer schools, community colleges, and adult education.

### **Meta-analysis of Curricula Effects on Achievement**

The objective of this chapter is to evaluate the effectiveness of the innovative science curricula on student science achievement. A major problem in determining the effectiveness of curricula innovations has been how to integrate the findings of numerous, often contradictory, related studies. Fortunately, the meta-analytic technique developed by Glass (1976) provided a means for researchers to summarize the results of the research on the effect of curricula on science achievement.

In this chapter, the results of meta-analyses are synthesized to build a comprehensive picture of the effects of the innovative curricula on science achievement. These analyses include the work of Becker (1989); Kavale (1988); Tamir (1985); Wilson, (1983); Kulik and Kulik (1982); and Weinstein, Boulanger, and Walberg (1982); as well as the Science Meta-analysis Project (1983). This project, a multi-institutional effort, was designed to "integrate the findings of extant research studies directed toward the major science education research questions" (Anderson, Kahl, Glass, & Smith, 1983). The results of this project were re-analyzed in 1987, using improved meta-analytic methods (Shymansky, Hedges, Woodworth, 1987).

### **Innovative Science Programs**

Beginning in the 1960s, science curricula underwent a major overhaul. Between 1959 and 1973, 19 innovative science curricula projects for grades 7 to 12 were funded at a cost of 92 million dollars by the National Science Foundation (Weinstein, Boulanger, & Walberg, 1982). The authors also mentioned that these projects included both summer and full-year teacher institutes to train teachers to use



the new curricula, and evaluation studies of the effectiveness of the innovative curricula compared to traditional curricula methods.

The innovative science curricula were distinctly different from the traditional curricula. Unlike the pre-Sputnik science curricula, which emphasized the acquisition of facts, the innovative curricula stressed the processes involved in scientific research (Shymansky, Kyle, and Alport, 1983). The innovative curricula stressed the scientific method as a tool to be used in solving problems. The innovative curricula also stressed laboratory skills, inquiry, and group investigation. Unlike the earlier curricula which relied heavily on teacher lecture, the innovative science curricula emphasized active student involvement in the learning process.

The most widely implemented secondary science curricula included Biological Science Curriculum Study (BSCS), CHEM Study, Introduction to Physical Science (IPS), Harvard Project Physics, and Physical Science Study Committee Physics (PSSC).

## **Biology**

When referring to the study of biology, innovative science curriculum is synonymous with BSCS biology (Shymansky, Kyle, & Alport, 1983). The BSCS approach involved students in applying scientific methods to solve meaningful problems. In seeking solutions, students developed hypotheses, designed experiments, and drew conclusions. To develop within students an understanding of the process of science rather than just the products of science (Schwab, 1965), BSCS emphasized

the inquiry method. The aim of this approach was to develop within students a pattern of scientific reasoning that leads to discoveries.

BSCS was an extremely effective innovative curricula compared to traditional biology courses (Shymansky et al., 1983; Shymansky, 1984). Students taking BSCS biology had significantly higher student achievement than students taking traditional biology courses. The effect size (ES)<sup>3</sup> for achievement (fact/recall, synthesis/analysis, and general achievement) was 0.59. [An effect size of 0.2 or less is a small effect; 0.5-0.6, a medium effect; and 0.8 or greater, a large effect (Cohen, 1980)]. Other effect sizes were process skills (0.90), analytic skills (0.46), and perceptions (0.82).

## Chemistry

Two major innovative chemistry curricula--Chem Study and CBA--were implemented during the 1960s. Shymansky et al. (1983) reported that these two curricula were the least effective of the new science curricula. The mean effect size for achievement was 0.16, compared to 0.59 for BSCS. The innovative chemistry curricula had only very slight positive effects on process skills (0.02) and only modest improvement in process skills (0.28).

Nevertheless, students in innovative chemistry programs did perform slightly better than students in traditional chemistry courses.

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<sup>3</sup>Effect size =  $(M^e - M^c) / \underline{s}$ , where  $M^e$  and  $M^c$  are the experimental and control group means, respectively, and  $\underline{s}$  is the standard deviation.



## **Physical Science**

A variety of innovative physical science programs were developed in the years following Sputnik. These curricula included the Human Science Program (HSP); Time, Space, and Matter (TSM); Individualized Science Instructional System (ISIS); Intermediate Science Curricula Study (ICS); Introductory Physical Science (IPS); Interaction of Matter and Energy (IME).

Shymansky et al. (1983) reported that these innovative physical science curricula "had a positive impact on the student participants." (p. 394) The overall effect size for achievement was 0.31; for process skills (0.08), analytic skills (-0.10), and perceptions 0.31. The authors concluded that the only negative effect of the innovative curricula was in the area of problem solving. Students in the innovative physical science programs did show higher achievement than students in traditional courses.

## **Physics**

The Physical Science Study Committee (PSSC) Physics was one of two widely adopted innovative physics programs during the 1960s. The meta-analysis by Shymansky et al. (1983) calculated that the effect size for overall achievement was 0.50, for process skills (0.33), and for analytic skills (0.53). The authors concluded that overall student gains in performance in physics were second only to the BSCS biology. The authors found that students in PSSC physics showed a higher achievement than students in traditional courses, gaining a grade equivalent of at

least one-half year over students in traditional physics courses in general physics achievement and analytical thinking skills.

The second innovative physics program was Harvard Project Physics. This program de-emphasized mathematics, adopting instead a humanistic, historical approach. A four year evaluation project of Harvard Project Physics (Welch, 1973) found that although science achievement was not significantly higher compared to traditional physics courses, students in Project Physics developed a much more positive attitude toward physics. Students in Project physics reported the course more "satisfying, diverse, historical, philosophical, humanitarian, and social." (p. 375)

#### **How Effective were the Innovative Science Curricula?**

Both the BSCS and the PSSC physics were much more effective than traditional curricula in raising student achievement. The innovative physical science curricula also resulted in higher student achievement compared to traditional methods, although to a lesser extent than the innovative biology and physics curricula. The chemistry curricula were the least effective of the innovative curricula. Nevertheless, students in innovative chemistry programs did perform slightly better than students in traditional chemistry courses.

It may be concluded therefore that in general the innovative science curricula had a positive effect on student achievement. Referring to the research premise presented in Chapter 2, if all of the other variables--students, teachers, and school climate--had remained unchanged, then student achievement in science should have improved as a result of the implementation of the innovative science curricula.



## **Instructional Strategies**

The 1960s and 1970s witnessed the introduction of numerous instructional approaches that were designed to incorporate results of learning theory research. The new approaches structured the presentation of information for the learner, provided motivational techniques, encouraged critical thinking, and tailored presentation methods to meet individual learner differences. These new approaches were accompanied by other changes in the learning climate that included less reliance on ability grouping, the move toward smaller class sizes, and the introduction of state-of-the art audio-visual technology. In this next section, the effectiveness of these educational changes in improving student achievement are discussed.

### **Innovative Instructional Approaches**

*Advance Organizers.* Ausubel (1963) developed the concepts of advance organizers to introduce a learning task. The advance organizer relates the material to be learned to previously learned material and helps the learner to structure what is to be learned.

Stone (1983) integrated the results of 29 studies on the effectiveness of advance organizers on achievement. Lott (1983) combined the results from 16 studies on the effectiveness of advance organizers in science education. The effect size for knowledge was 0.09. For application of knowledge, the effect size was 0.77. The combined cognitive effect size was 0.24. The results showed that advance

organizers both increased achievement and improved learning retention compared to students taught without the benefit of advance organizers.

*Cues and Reinforcement.* Lysakowski and Walberg (1982) conducted a meta-analysis on the effectiveness of cues, reinforcement. They found that students in science classes that used cues and reinforcement outperformed students in the control group. The meta-analysis synthesized the results of 54 studies that included 14,689 students in approximately 700 classes. Lysakowski and Walberg found a mean effect size of 0.97 students in classes that used cues and reinforcement. This effect size placed treatment groups on the average at the 80th percentile compared to control groups. Furthermore, the authors reported that these findings were constant for all levels of education from elementary through college. The findings were constant consistent across socio-economic level, race, and community type, and the findings were valid for public- and private-schools.

*Computer-Based Instruction.* The determination of the effectiveness of computer-based instruction on science achievement was complicated by three factors (Roblyer, Castine, and King, 1988). First, most of the earliest studies examined the use of mainframe computers in science education. (Personal computers, or minicomputers, in education are a more recent innovation.) Second, many of the early PC studies did not have access to adequate numbers of machines. Third, the quality of



educational software has varied greatly across the studies of the effectiveness of computer-based education.

Roblyer, Castine, and King (1988) conducted a meta-analysis of studies on the effectiveness of computer-based instruction. These authors found that computer-based instruction was effective in raising science achievement ( $ES=0.49$ ), although the authors did caution that the small number of studies limited the conclusions that can be drawn. The authors also found that the effectiveness of computer-based instruction varied across subject field, being more effective in mathematics than reading. The cross-subject finding was confirmed similar findings in earlier meta-analytic reviews. In sharp contrast to previous reviews, which found that computer-based instruction was most effective with low level students at the elementary level and with males, Roblyer et al. found that computer-based instruction was not significantly more effective for lower scoring students or for males. The authors also found that computer-based instruction was most effective at the college level, which was contradictory to previous studies that had found that computer-based instruction was most effective at the elementary level.

(Kulik & Kulik (1987b, c) synthesized the results of five separate meta-analyses on the effectiveness of computer-assisted, computer-managed, and computer-based instruction. The authors concluded that computer-based instruction 1)

improved student achievement, 2) reduced instruction time, and 3) improved student attitudes toward both the subject matter and computers.

In a prior meta-analysis of computer-based instruction, Bangert-Drowns, Kulik, and Kulik (1985) reviewed 42 studies of the effectiveness of computer-based instruction in secondary schools. In this meta-analysis, the effectiveness of computer-based programs was also found to be greatest for low-aptitude students. In another 1985 analysis of 12 studies, Okey found that computer-based science instruction was very effective (0.82).

Willet, Yamashita, and Anderson (1983) reviewed 14 studies on computer-based instruction. The authors reported that computer simulations had the largest effect on achievement ( $ES = 1.45$ ). Computer-aided instruction was the least effective, improving achievement only slightly ( $ES = 0.16$ ). Orlansky (1983) reviewed 48 studies of military training classes that were taught using traditional or computer-based methods. He reported that although computer-based instruction was not more effective than traditional methods, students in computer-based classes learned the material in 30% less time.

Kulik, Bangert-Drowns, and Williams (1983) and Kulik and Bangert-Drowns (1983-1984) integrated the findings of previous meta-analyses and concluded that programmed instruction was only mildly effective ( $ES=0.1$ ), but that computer-based



instruction raised student achievement by 0.4 standard deviation--i.e. from the 50th to the 66th percentile.

Although the research on the effectiveness of computer-based instruction is still somewhat preliminary, it does strongly suggest that computer-based instruction has great promise as a tool to help improve student science achievement.

*Inquiry.* Suchman (1962) and Schwab (1965) developed the inquiry method to teach BSCS biology. The concept of inquiry, which grew out of psychological learning research, was designed to teach students to process scientific information using the scientific method to solve problems.

Wise and Okey (1983), as a part of the Science Meta-analysis Project, investigated the effectiveness of inquiry or discovery on student science achievement. The mean effect for cognitive outcomes (low and high level outcomes, general achievement, and problem solving) was 0.41; for affective outcomes the effect size was 0.15. Lott (1983) combined the results from 24 studies on the effectiveness of inquiry in science education. He calculated an effect size for knowledge of 0.02; for application of knowledge, -0.10; for process skills, 0.29; and for problem solving, -0.01. The combined cognitive effect size was 0.24.

Anderson (1983) in consolidating the results of the Science Meta-analysis Project reported that four different meta-analyses supported the effectiveness of inquiry teaching. He concluded that "all of the data from these meta-analyses favor

an inquiry approach, although the evidence varies in its strength from one meta-analysis to another." (p. 502)

*Mastery Learning.* Bloom and Carroll (1968/1971) developed a method of instruction called mastery learning in which students must reach performance levels essential for basic competence (Torshen, 1977). In mastery learning, a student masters each objective before proceeding on to the next one. A unique characteristic of mastery learning is that individual students progress through the objectives at their own pace.

The effectiveness of mastery learning has been extensively studied. Guskey and Pigott (1988) conducted a meta-analysis of 46 studies on mastery learning strategies in group environments. Their analysis concluded that mastery learning improved both cognitive and affective learning outcomes.

Kulik and Kulik (1987a,) synthesized the results of 49 studies on mastery learning. The researchers found the mastery learning approach was most effective in improving student achievement for low aptitude students.

Slavin (1987) used a modified meta-analytic/narrative technique, called "best evidence synthesis," which he had developed to integrate the research findings on mastery learning. Slavin, in contrast to the other researchers, found no evidence that mastery learning improved achievement.

Willet and Yamashita (1983) used meta-analysis to combine the results of 10 studies on the effectiveness of mastery learning. They calculated an effect size of 0.50 for science achievement with similar gains on affective measures. They also



reported that mastery learning significantly improved skills in scientific methods ( $ES=1.24$ ) and critical thinking ( $ES=0.89$ ).

*Personalized Instruction.* During the last 30 years, tutoring of disadvantaged students has become increasingly common. Both the Head Start program for minority students and the Migrant Education program utilized tutoring as a method to try to improve the educational opportunities for at-risk students. In addition, tutoring has become a widely accepted practice in special education programs and in cooperative learning in general classes.

Cohen (1981) conducted a meta-analysis on the effectiveness of tutoring in improving achievement. The results of the meta-analysis showed that tutoring improves achievement and attitude toward the subject for the student being tutored. Cohen also reported that tutoring programs improved the self-concept the tutor and the self-concept of the student being tutored.

Willet, Yamashita, and Anderson (1983) investigated audio-tutorial, learning contracts, individualized instruction, media-based instruction, Personalized System of instruction, programmed learning, self-directed study, and team teaching. They found that the most successful was the Personalized System of Instruction with a cognitive effect size of 0.49, followed by contract learning (0.22) and programmed instruction (0.17). Audio-tutorial (0.09), individualized instruction (0.12), and team teaching (0.09) are only very slightly more effective than traditional teaching. The only

negative effect sizes were reported for self-directed study (-0.02) and media-based instruction (-0.03).

### **Other Instructional Trends**

*Ability-Grouping Practices.* The grouping of students by ability was an accepted educational practice prior to the 1960s. A second generally accepted practice was the encouragement of individual student competition for grades. However, these practices became less widely used after 1964. First, the integration of schools in the 1960s and then the federal requirement in the 1970s to mainstream exceptional students caused tracking of students to become less popular. Instead, the trend was to place students in the "least restrictive environment," which encouraged a move toward heterogeneous classes and away from homogeneous classes and tracking. Rock et al. (1985) found the percentage of schools using ability grouping declined from 59.5% in 1972 to 51.2% in 1980.

Some critics have argued that the shift from ability grouping to heterogeneous classes could be a likely contributor to the decline in student achievement in science. However, this criticism is not supported by the research. Noland and Taylor (1986) conducted a meta-analysis of 50 studies on ability grouping between 1967 and 1983. The results of the meta-analysis showed that ability grouping did not result in higher achievement, but that ability grouping did lower student self-concept for ability-grouped students compared to students in heterogeneous classes.

*Audio-Visual Technology.* The libraries of the 1960s were transformed into the media centers of the 1980s. Formerly a place to find books, the media center became a



repository of learning materials and "teaching" equipment such as VCRs, television monitors, tape recorders, and film projectors. Unlike the pre-1960s teacher, whose audio-visual equipment consisted of the blackboard and whatever else could be fashioned from paper, crayons, or glue, most science teachers in recent decades had access to all kinds of sophisticated electronic and film resources to enhance teaching.

But how effective has all of the innovative audio-visual equipment been in improving student achievement? Wise and Okey (1983) conducted a meta-analysis on the effectiveness of audio-visual methods. The authors calculated a cognitive effect size of 0.1, which indicates that innovative audio-visual methods had only a slight positive effect on student achievement.

*Smaller Class Size.* A second curricula factor that has changed since the 1960s is class size. As school funding increased, more teachers were hired. At the same time school enrollment stabilized and teacher contracts placed limits on class size. As a result, average class size decreased throughout the 1970s and 1980s. In 1960 the average secondary pupil-teacher ratio was 21.7<sup>4</sup>. Between 1970 and 1980, the pupil teacher ratio fell from 19.9 to 16.9. By 1988 the pupil-teacher ratio had fallen to 14.7 (*Education Indicators*, 1989).

Robinson and Wittehols (1986) used a cluster-analysis approach to synthesize the results of 100 studies conducted between 1950 and 1985 on the relationship

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<sup>4</sup>Many educators criticize class size statistics because they may include guidance counselors and administrators, which means that the numbers do not present an accurate estimate of actual class sizes. While this argument is valid, the actual class sizes are not important in this analysis. What is important is that average class size has declined throughout the last 30 years.

between class size and student achievement. The results were found to vary with grade, subject matter, and instructional method; with the effect of class size on student achievement decreasing at higher grade levels.

Fliss (1984) performed a meta-analysis on class size. The results of this meta-analysis found that class size had little effect on achievement for class sizes between 25 and 40; and that class size was the greatest effect on achievement for class sizes of fewer than 20 students. Fliss concluded that there is no one optimum class size.

Smith and Glass (1980) combined the results of 59 studies on class size. They concluded that class size was related to student attitude and the method of instruction used, but that class size had very little direct effect on student achievement.

### **How Effective were the Instructional Strategies?**

The body of research on the effectiveness of these innovative instructional approaches and instructional trends indicates that like the innovative science programs these changes should have improved student science achievement. All of these innovations and trends have been shown separately to have a positive effect on achievement.

### **Conclusions**

Weinstein, Boulanger, and Walberg (1982) analyzed 33 studies of innovative high school science programs that involved a total of 19,149 junior and senior high school students in the United States, Great Britain, and Israel. They concluded that:

the post-Sputnik (1958) curricula produced beneficial effects in science learning that extended across science subjects in secondary schools,



types of students, various types of cognitive and affective outcomes, and experimental rigor of the research. . .the present analysis shows a moderate 12 point percentile advantage (effect size = 0.31) on all learning measures of student performance in the innovative course. (pp. 518-519)

The authors reported that the effect sizes were significant at the 0.05 level, and that student performance in the innovative curricula averaged at the 62nd percentile compared to traditional science programs.

The meta-analysis by Shymansky et al. (1983) included 105 studies of 27 different science curricula and 18 different student performance measures. The authors concluded that:

1. The average student in the new science curricula exceeded the performance of 63% of the students in traditional science courses on the aggregate criterion variable.
2. Across all curricula, students exposed to new science programs showed the greatest gains in the areas of process skill development, attitude toward science, and [science] achievement.
3. By content area, students exposed to new biology and new physics programs showed the greatest gains across all criteria measured, while new chemistry and earth science students showed the least gains. (pp. 401-402)

According to the authors, "there is a substantial body of research literature which collectively points to the new science curricula as a successful attempt to improve science education." Shymansky et al. also found that the innovative curricula improved student attitudes toward science and student self concept; as well as critical thinking, problem solving and mathematics achievement.

Shymansky et al. found that students in innovative science programs had an general achievement gain of 0.43 standard deviations--a gain of a half grade level--



over traditional science curricula. Boulanger (1981) in a study of innovative science curricula between 1963 and 1978 concluded that the new curricula improved science achievement compared to traditional science curricula.

Wise and Okey (1983) calculated an overall effect size for twelve different teaching techniques, including inquiry-discovery. The overall effect size which was based upon 160 studies was 0.34. The authors concluded that the innovative science instructional techniques resulted in one-third of a standard deviation in improvement when compared to traditional teaching methods.

Preece (1988) researched science education in the 1980s. Preece concluded that teaching techniques used in the 1980s were generally more effective than traditional methods. Based upon the research on curricula innovations since Sputnik, it is valid to conclude that these innovations had positive effects on student learning and should in themselves have resulted in improved student achievement in science during the last three decades. The results of the meta-analyses on the effect of curricula innovations on student achievement are summarized in Table 6.

As the table indicates, the innovative curricula, methods of instruction, and other curricula trends since the mid-1960s should have positively influenced student achievement. Therefore, these changes cannot be a cause of the decline in student achievement. On the contrary, student achievement should have steadily risen since 1957, based solely on the effectiveness of the curricula trends. When we consider that per-pupil expenditures (*Digest of Educational Statistics*, 1968; U.S. Department of Commerce, 1990) have more than doubled in the last three decades, it is not all



that surprising that the curricula and instruction are more effective today compared to traditional practices. And still, many of the current proposals for educational reform center again on revising the curricula or developing new methods of instruction to improve student thinking skills in an effort to improve science achievement.

TABLE 6

SUMMARY OF THE EFFECTIVENESS OF INNOVATIVE CURRICULA IN IMPROVING STUDENT ACHIEVEMENT

INNOVATION	EFFECT SIZE	STRENGTH OF EFFECT
BSCS Biology	0.46-0.90	moderate to strong
PSSC Chemistry	0.16	small
Physical Science	-0.10-0.30	small
PSSC Physics	0.33-0.53	small to moderate
Mastery Learning	0.82-1.24	large
Reinforcement	0.97	large
Simulations	1.45	large
Computer assisted instruction	0.10-0.16	small
Advance Organizers	0.09-0.77	small to moderate
Inquiry	-0.01-0.41	small
Heterogeneous classes		no effect
Personalized Instruction	-0.03-0.55	small to moderate
Class Size		small
Audio-Visuals	0.10	small

The research on the trends in curricula over the last 30 years does not support the claim (Murphy, 1990) that by the 1980s, "The curriculum was a mess, lacking both rigor and coherence. Instruction was poor; materials (textbooks) worse." (p. 10)

The results of the research on curricula trends suggest that the possible causes for declines in student science achievement have now been reduced by one. Either changes in teachers, students, or both must be the cause of the declines in student science achievement.



## **CHAPTER 5**

### **TEACHERS AND STUDENTS**

The research presented in Chapter 4 strongly suggests that changes in curricula were not responsible for the declines in student achievement during the last 30 years. On the contrary, the research has shown that specific innovations in science curricula and methods of instruction should have had a positive effect on student achievement. Based solely on the innovative curricula and instructional factors described in the previous chapter, student achievement in 1990 should have been significantly higher than in 1970.

In this chapter changes in teacher and student characteristics and changes in requirements for teachers and students are detailed. Since curricular innovations have been ruled out as a possible cause of declines in student achievement, changes in teachers or students, or both, must be related to the declines in achievement. The first variable to be considered is teacher characteristics.

#### **Teacher Characteristics**

Many of the educational reports released during the 1980s singled out teachers as a primary cause of the decline in student achievement in science. The 1983 report *A Nation at Risk* was especially critical of public school teachers. The report noted that "too many teachers are being drawn from the bottom quarter of graduating high

school and college students." (p. 30) The report also criticized schools of education because "41 percent of the time of elementary school teacher candidates is spent in education courses, which reduces the amount of time available for subject matter courses." (p. 30) In the areas of science and mathematics, the report found that half of the newly employed teachers were not qualified to teach these subjects. Similarly, the Twentieth Century Fund report, *Making the Grade*, placed much of the blame for declining student achievement on teachers. The report, *Action for Excellence* (1983), by the Education Commission of the States Task Force on Education for Economic Growth stated that the least able college students chose teaching careers. The report recommended that educational standards be increased for teachers.

A similar finding was reached by the National Science Board Report, *Educating Americans for the 21st Century* (1983). According to this report:

Many of the teachers in elementary schools are not qualified to teach mathematics and science for even 30 minutes a day. A significant fraction of our secondary school teachers are called upon to work in subjects for which they were never trained. Even the most seasoned and experienced veterans must deal with subjects that are in a state of constant change; no one can remain knowledgeable in science without constant refreshing. (p viii)

The report also called for retraining teachers and for raising standards both for beginning and for experienced teachers.

These reports assumed implicitly that 1) teacher quality had declined, and 2) the declines in teacher quality had contributed to the declines in student science achievement. However, as Rock et al. (1985) and Raywid, Tesconi, and Warren



(1984) pointed out, there was little available research that supported the claim that teacher quality had declined during the 1970s and 1980s.

### **Teacher Quality**

In sharp contrast to the conclusions of the commission reports of the 1980s, the National Education Association (1976) had reported that teachers in the 1970s were better prepared than their predecessors. This assertion was supported by trends in teacher training. In 1961, for example, fully 15% of all teachers did not have a bachelor's degree. However, by 1976 this number had been reduced to 1%. The trend with master's degrees was similar. In 1961, 23% of the teachers held a master's degree. By 1965 the percentage had increased to 29.6% (*Digest of Education Statistics*, 1968), and by 1980 the percentage of teachers with a master's degree had increased to 31.6% (Rock et al., 1985).

The results of a survey by the Metropolitan Life Insurance Company (1988) indicated that teachers agreed with the National Education Association view of teacher competency--not the view of the commission reports. According to the Metropolitan Life survey, 93% of the teachers surveyed disagreed with the statement that "other" teachers showed little expertise and personal knowledge in lecture materials. Moreover, 84% of the teachers surveyed disagreed with the statement that their colleagues had minimal learning expectations, and 75% did not believe that their colleagues just went through the motions of presenting information. On the contrary, the teachers (94%) who were surveyed said that their colleagues had a love

or passion for teaching; and exchanged ideas about teaching techniques and subject matter (89%).

Clearly, teacher and commission views of the state of the teaching profession were widely disparate. According to the Metropolitan Life Survey (1988), the majority of teachers talk with students outside of class about student interests and student personal problems. Teachers (99%) agreed that most teachers in their schools care about students. Ninety-eight percent said that their colleagues treated students fairly and encouraged them to reach their maximum potential. The teachers surveyed said that they regularly encouraged student participation (96%), recognized student performance (91%), gave students individual attention (81%), and organized classes to interest students (78%).

This view of teachers--knowledgeable of their subject and teaching methods and dedicated to the profession--was also reported by students. According to the 1988 Metropolitan Life Survey:

The overwhelming majority of both teachers and students report that the student-teacher relationships in their schools are either good or excellent. . .Almost all teachers (93%) rate the relationship between teachers and students in this way, as do 70% of all students. . .It is clear from the responses of both teachers and students that most teachers' commitment to the profession extends beyond the classroom. (p. 49)

The absence of a decline in teaching quality was further supported by student ratings of teaching trends. Between 1972 and 1980, there was little difference in student ratings of quality of instruction, difficulty of courses, and teacher-interest in students (Rock et al., 1985). In both years (Table 7), more than 50% of the seniors



reported that student-centered discussions were used fairly often or frequently used. Similarly, in both years more than 60% of the students reported that writing assignments were frequently given. According to the same study, the amount of student laboratory work did decrease somewhat during the 1970s, but the use of individualized instruction and computer-based instruction increased during this same period.

TABLE 7

PERCENTAGE OF PUBLIC SCHOOL SENIORS WHO REPORTED  
TEACHING METHODS "FAIRLY OFTEN" OR "FREQUENTLY USED" IN  
COURSES: 1972 AND 1980

TEACHING METHOD	1972 SENIORS	1980 SENIORS
Student-centered discussions	59.3	55.8
Project or laboratory work	48.0	43.0
Writing essays, themes, poetry, or stories	63.9	61.3
Individualized Instruction	23.3	26.2
Teaching machines or computer-assisted instruction	12.0	16.4
Source: Rock et al., 1985		

During the 1970s, students continued to look to teachers as role models. Thirty-nine percent of high school students said that there were teachers that they admired and would like to be like. Between 1972 and 1980 the number of students

who reported that teachers strongly influenced their post-secondary plans increased (Rock et al., 1985).

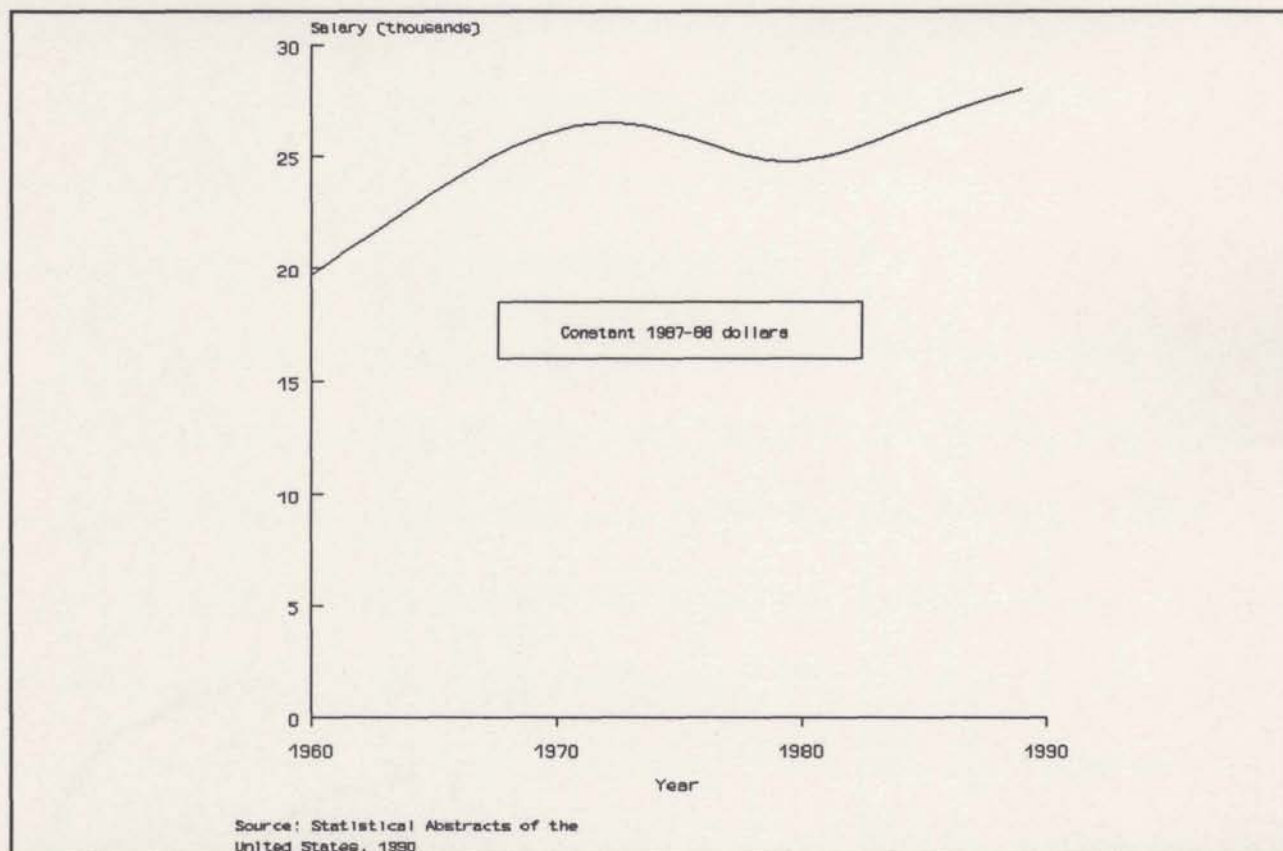
Obviously, teachers and students held a very different view of teacher competency than did many of the commission reports. While the commission reports strongly criticized teacher quality, the students and teachers said that teachers were doing a good job. But what did principals, school superintendents, and deans of colleges of education say about the quality of recent teachers? Did school management agree with the teachers or with the commission reports? According to the 1986 Metropolitan Life Survey, principals (44%), superintendents (51%), and deans (60%) rated the overall quality of new teachers entering the profession as better than the quality of new teachers in the past. It is interesting to note, however, that according to the same survey only 33% of state legislators and state education officials, and 17% of teacher union officers agreed.

Before drawing any conclusions about the direction of any trend in teacher quality since 1960, one final factor needs to be considered. That factor is changes in requirements for education majors, beginning teachers, and experienced teachers.

One outcome of the commission reports of the 1980s was a national drive to improve teacher quality for both veteran and beginning teachers. Most of the states followed the recommendations of the reports in raising teacher salaries (Figure 15). Related innovations during this period included the introduction of performance-



based pay, career ladders, and professional development programs (*The Nation Responds*, 1984).



**Figure 15.** Trends in Teacher Salaries Since 1960

In many states teacher salary reforms were accompanied by demands for greater teacher accountability. In some states, teacher competency was measured in terms of how well a teacher's students performed on competency examinations. In other states, such as Texas, increased teacher accountability meant that veteran teachers would have to pass competency tests in order to remain certified to teach.

The state reforms also targeted undergraduate education majors and beginning teachers. The demand for better teachers led many colleges of education to

strengthen their teacher training programs. Scholarships were made available for promising undergraduate students preparing to teach science. By 1989, 32 states required students to pass an examination in order to be admitted to a teacher education program (*Education Indicators*). By 1990, 43 states required beginning teachers to pass written examinations to demonstrate that they were qualified to teach (*Digest of Education Statistics*, 1989 [p.146]).

In summary, the proportion of teachers with college degrees and with advanced degrees increased sharply during the 1970s and 1980s. The results of various educational surveys further support the argument that teacher quality has improved since the 1960s. It would seem therefore that the national commission reports were wrong in their claim that teacher quality had seriously declined during the 1970s and 1980s. On the contrary, the evidence clearly supports the contention that teachers were dedicated and qualified. Certainly, there seems to be scant evidence that could be used to make a case for a negative trend in teacher quality, which could be used to explain the declines in student achievement in science.

### **Teacher Attitudes**

One of the characteristics of the commission reports was that they were written variously by college deans, school superintendents, political figures, corporate officials, and professors. Noteworthy by their absence were classroom teachers. For example, the Education Commission of the States Task Force on Education for Growth (1983) report, *Action for excellence: Task Force on Education for Economic Growth* had 42 members, but only one member was a teacher (Murphy, 1990). In



a similar fashion, the National Science Board (1983) report, *Educating Americans for the 21st century* was composed of 19 members--one of whom was a teacher.

Another example of the failure of the commission reports to include teachers was the Twentieth Century Task Force on Federal Elementary and Secondary Educational Policy (1983). This task force, which released the report, *Making the Grade*, was composed of 12 members; none of whom was a teacher. The most famous of the commission reports, *A Nation at Risk* was written by the National Commission on Excellence in Education. This commission had one teacher among its 18 members. The most extreme example of the lack of teacher representation was the Boyer (1983) report, *High School*. There were no teachers among the 29 members of the commission responsible for this report.

Given the lack of representation, it is not all that surprising that many teachers did not agree with many of the assessments and proposed solutions of the commission reports. For example, in the Metropolitan Life Survey, of 1208 teachers surveyed, 84% did not agree with the commission reports that proposed schools of choice as a vehicle for overcoming students' educational disadvantages. The teachers surveyed were less critical of magnet schools and specialized schools, with teachers just about equally split on the educational value of such schools in helping to overcome students educational disadvantages.

Concerning the issue of accountability, teachers disagreed with the report, *A Nation at Risk*. Sixty-nine percent of the teachers surveyed did not feel that teachers and principals should be held more accountable for students who were failing.

Teachers also disagreed with the educational reports that maintained that the dropout rate was a serious school problem. Only 9% of the teachers agreed that dropouts were a very serious problem. Furthermore, teachers did not believe that schools were responsible for most student dropouts. Ninety-two percent of the teachers agreed that the most important cause of students dropping out was family problems.

Teachers did strongly agree with the commission reports on one point--standards. Nearly 75% of the teachers felt that students should have to reach specified standards to be promoted. Similarly, 61% agreed that more money should be provided for schools with special problems. Some education solutions proposed by teachers are listed in Table 8.

A significant part of teacher perceptions about education involved the school working conditions, school climate, and student characteristics. Table 9 lists some teacher perceptions of their working conditions. As shown in the table, 38% of the teachers surveyed reported that their colleagues felt isolated from other educators, and 80% felt that teachers were frustrated with administrative practices. Seventy-nine percent of the teachers surveyed agreed that they themselves were frustrated with administrative practices at their schools. In this regard, only 60% of the teachers reported that they were able to devote at least 75% of their class time to teaching.



TABLE 8  
TEACHER PROPOSED SOLUTIONS TO CURRENT EDUCATIONAL  
PROBLEMS

PROPOSED SOLUTION	WILL HELP A LOT (%)
Allow the students to choose the school they want to attend	16
Establish and maintain support structures such as health and guidance counseling	77
Establish and maintain after-school activities such as arts and sports	66
Assign teachers a group of students for several years to provide continuity	30
Develop before and after school educational programs	44
Have specified standards that students must reach before they can be promoted	64
Hold the principals and teachers more accountable to students who are failing	31
Allocate more money to schools with special problems	61
Establish magnet or regionalized schools with specialized curricula	48
Establish specialized programs or schools for 10 to 14 year-old students	45
Source: Metropolitan Life Insurance Company, 1988	

Teacher frustration may have been an important factor related to increased numbers of teachers changing schools or leaving the profession during the 1970s. Between 1972 and 1980, the percentage of schools with a 10% or greater turnover rate increased from 37.8% to 46.2% (Metropolitan Life Insurance Company, 1988).

The dropout rate for teachers, however, did vary considerably among the teaching disciplines. For example, Murname (1987) found that in Michigan 55% of the physics teachers and 51% of the chemistry teachers were no longer in the classroom after 5 years, compared to 39% of the history teachers. In a subsequent study, Murname (1989) found that only 14.6% of physics and chemistry teachers who left teaching before 6 years returned to the classroom.

As Table 10 indicates, the flight from the classroom coincided with changing teacher perceptions of the viability of teaching as a career. In 1961, only 40% of the secondary teachers surveyed reported that if they had it all to do over again they would become teachers (*Digest of Education Statistics*, 1985). Male teachers were less favorable, with 35% agreeing, compared to 57% of female teachers. A decade later in 1971, the percentage of teachers who reported that they would choose to teach again had not changed significantly (39%). However, teacher attitudes toward the profession changed radically during the 1970s. As a result, in 1981 only 18% of secondary teachers said that they would be willing to teach again. Thus, in 1981, compared to a decade earlier, only half as many teachers were willing to teach again.

The Metropolitan Life Survey (1988) reported similar findings. Begun in 1984 the results of the survey first indicated an upswing in 1988 in the percentage of teachers reporting that they were very satisfied with teaching as a profession. However, the increased satisfaction was reported by females and by teachers with



TABLE 9

## TEACHER PERCEPTIONS OF WORKING CONDITIONS

PERCEPTION	AGREE STRONGLY OR SOMEWHAT (%)
My classes have become so crowded that I can't get to know every student	23
My classes have become so mixed in terms of students' learning abilities that I can't teach them effectively	39
My school does not encourage strong relationships between students and teachers	10
I don't relate to some of my students because my background is so different from theirs	13
There is a lack of parental support for developing positive student-teacher relationships	65
I have so many non-educational responsibilities that I don't have time to develop positive relationships with students	40
Some of my students are not interested in getting an education	76
A lot of teaching that goes on seems impersonal and mechanical	40
Schools have become a place just to earn a paycheck	10
Source: Metropolitan Life Insurance Company, 1988	

more than 5 years of teaching experience. Satisfaction of teachers with less than 5 years of experience declined.

On the other hand, the percentage of teachers who reported that they were likely to leave teaching did not change between 1985 and 1988, with 26% of teachers

reporting that they were "fairly likely" or "very likely" to leave teaching within the next 5 years. Among teachers with fewer than 5 years experience, 34% reported that they were likely to leave teaching; among minority teachers, 41% reported that they were likely to change careers within 5 years.

TABLE 10

PUBLIC SECONDARY TEACHERS WILLING TO BECOME TEACHERS  
AGAIN

YEAR	TOTAL (%)	MALE (%)	FEMALE (%)
1961	40	35	57
1966	45	38	39
1971	39	33	51
1976	32	27	42
1981	18	16	25
1983	20	19	27
Source: <i>Digest of Education Statistics</i> (1985)			

The perception of the public about the desirability of teaching as a career showed a drop that was similar to the change in teacher perceptions found in the Carnegie survey. In 1989 58% of the parents in the Gallup survey said that they would like one of their children to become a public school teacher. By 1990, the favorable response rate had dropped to 51%. The drop in popularity of teaching as a career was accompanied by two other negative perceptions of public education. First, 50% of the respondents felt that teachers were underpaid. And second, people



do not believe that the educational reforms have improved public schools. Only 20% of the people surveyed felt that schools in their community had improved within the last 5 years.

The upswing reported in the Metropolitan Survey was subsequently contradicted by the national survey released by the Carnegie Foundation for the Advancement of Teaching in September, 1990. The Carnegie survey found that there was a broad teacher dissatisfaction with the profession due to teachers' lack of authority over their working conditions. In fact, 45% of the teachers surveyed reported that they "were unhappy with the control they had over their professional lives," as against 25% in 1987; and 70% of teachers surveyed reported that they had little or no involvement in establishing policies for student promotion and retention (Celis, 1990). Teacher complaints included the frustration with the outcomes of the "Excellence" movement. Other teacher complaints included students' lack of drive and ambition, and the growing inability of schools to meet student needs.

The influence of the school climate on teacher perceptions was clearly shown by differences in perceptions of minority and non-minority teachers, who were much more likely to teach in urban schools with high percentages of students who were academically handicapped. Approximately 41% of minority teachers taught in inner-city or urban schools, compared to 17% of the non-minority teachers. Table 11 lists minority and non-minority teacher perceptions. The most striking differences in

perception involved student-teacher relationships, teenage pregnancy, and alcohol and drug use, and dropouts.

The evidence supports the conclusion that factors other than teachers or curricula may have operated to change the school climate and student characteristics, which in turn have influenced student achievement. In this next section, changes in student attitudes and behaviors and teacher perceptions of student changes will be examined to identify other changes related to declines in student achievement.

TABLE 11

## TEACHER PERCEPTIONS OF THE SCHOOL CLIMATE

PERCEPTION	MINORITY (%)	NON- MINORITY (%)	TOTAL (%)
The number of students who lack basic skills is a serious problem	21	15	16
Many or all of the students are from minority families	56	20	24
Student-teacher relationships are excellent	26	42	40
Dropouts are a serious problem	16	8	9
Teenage pregnancy is a serious problem	23	10	12
Student alcohol use is a serious problem	26	34	33
Student drug use is a serious problem	21	13	14
Violence is a serious problem	7	3	4
Source: Metropolitan Life Insurance Company, 1988			



### **Student Characteristics**

The relationship between student characteristics and achievement is well documented. Numerous studies have linked student achievement to socio-economic status, parental educational levels, racial or ethnic background, and attitude toward school (Applebee, 1989; Lapointe, 1989; Carnegie Foundation, 1990). Similarly, a number of studies have found a relationship between the amount of homework that a student does and student achievement. Other studies have found relationships between the amount of television viewing and student achievement. In this section changes in student characteristics related to science achievement are discussed.

#### **Attitudes and Behavior**

The Educational Testing Service (ETS) study of factors associated with declines in test scores of high school seniors (Rock et al., 1985) found that there were significant changes in high schools and in student behavior between 1972 and 1980. Rock et al. (1985) concluded that changes in student behaviors were slightly more important than changes in the school climate in relation to the declines in mathematics achievement.

The ETS study found that throughout the 1970s, students became increasingly concerned with making money and less concerned with making social contributions. At the same time students had become less satisfied with their schools. Significantly more students in 1980 than in 1972 believed that their schools did not place enough

emphasis on academic subjects, but at the same time slightly more students reported that courses were too hard.

In a survey by the Metropolitan Life Insurance Company (1988), although 76% of the students reported that they wanted to do well, only 51% said that they got upset when they got a low grade. Fifty-five percent of the students said that they did not care one way or the other about going to school or that they really did not like going to school.

The change in student attitudes was accompanied by changes in student behavior. In the survey by the Metropolitan Life Insurance Company (1988), 32% of the students surveyed reported that they listened in science nearly all the time; 32% reported that they listened most of the time. But 21% reported that they listened only some of the time, and 12% reported that they almost never listened. Rock et al. reported in their 1985 survey that 65% of the students indicated that class-cutting was a problem in their school. In the same survey, 54% of the students cited poor attendance and 29% reported student fighting as problems.

The student opinions were shared by school administrators and teachers. By 1982 over 48% of administrators considered student absenteeism to be a moderate or serious problem; 42% cited student drug use and 30% mentioned class cutting as serious school problems (*High School and Beyond Survey*, 1982). In a Metropolitan Life Survey (1988), teachers reported that students paid less attention than in previous years. Only 36% of the teachers reported that their students were actually



paying attention more than 75% of the time; and 22% reported that students paid attention only between 26 and 50% of the time.

Apparently, the 1980s educational reforms, which stressed student discipline, had little overall effect on student behavior. According to the 1988 Metropolitan Life survey, 72% of the teachers surveyed said that disruptive behavior had stayed the same or increased during the last 5 years. Furthermore, of the teachers surveyed, 50% said that school discipline policies were inconsistently applied.

Another change in student behavior was in the use of alcohol and drugs. Although the use of alcohol has declined since 1980 (*Education Indicators*, 1989), nearly two-thirds of the seniors surveyed said that they had used alcohol in the month preceding the survey. Between 1975 and 1979 student use of cocaine doubled from 6% to 12%, declining to 8% by 1988. However, this survey did not include student use of crack, a cheap highly addictive form of cocaine, so that the trends of crack use are unknown.

Changes in the attitudes of parents and students toward schools were also evident in the courts. Between 1971 and 1977, there were 1734 civil cases in the United States involving students (*The Condition of Education*, 1982). These cases involved discipline, regulation of sports, benefits and services from schools, school prayer, curricula, freedom of speech, educational malpractice, and the right to a diploma. The increased tendency to sue school systems could indicate not only

changes in student behaviors, but also changes in the way parents viewed the role and authority of schools to control curricula and student behavior.

That parents have come to expect a greater role and increased authority over various school functions was demonstrated in the 22nd Annual Gallup Poll (Elman, 1990). Fifty-nine percent of the 1,594 adult respondents felt that parents should have more to say about the allocation of school funds. Fifty-three percent of the people interviewed expressed the belief that parents should have a greater role in determining the curriculum. The extent to which the public has come to expect active involvement in public schools was further indicated by the fact that approximately 40% of the adults surveyed felt that parents should have a greater voice in the selection, hiring, and setting of salaries of teachers and administrators, as well as in the selection of books and instructional materials.

### **Homework and Television Viewing**

Declines in the amount of homework was a frequently cited criticism in many of the national educational reports. And yet, the amount of homework only declined from 4.55 to 4.05 hours per week, or roughly 10% between 1972 and 1980 (Rock et al., 1985). In the 1988 Metropolitan Survey, 68% of the student reported that they spent an hour or more per night on homework.

Related to homework in an inverse way is the number of hours that students spend watching television. According to the Metropolitan survey, 12% of students watch 8 or more hours of television per day. Forty-nine percent of students watch



between 2 and 5 hours of television per day. Twenty-seven percent watch fewer than 2 hours of television.

### **Demographics**

Between 1972 and 1980 the number of high school seniors in public schools was nearly unchanged; however, the composition of the senior group changed significantly. In 1972, White students were 85.8% of the senior enrollment; by 1980 the proportion of White students had declined to 79.9% (Rock et al., 1985). The same study reported that at the same time, the enrollment of Black students increased from 8.7 to 11.6%. Hispanic enrollments increased from 3.5 to 6.5%. The gender composition of the senior class also changed between 1972 and 1980, with females increasing from 50 to 51.4% of the total population.

During this 8-year period, in addition to the changes in the makeup of the senior class due to increased numbers of females and minority students, there was also a sizable population shift from the Northeast and North Central regions of the country to the sun belt states. There was also a population shift away from urban to suburban areas. In 1972, an estimated 26.5% of the high school seniors were from urban areas; by 1980 only 20.1% were from these areas. The percentage of seniors

from rural schools increased from 21.6% to 30.5%, while the percentage from the suburbs changed by less than 3%.

### Course-Taking Patterns

Rock et al. (1985) reported that during the 1970s a greater percentage of high school students had enrolled in general, rather than academic courses. The report, *A Nation at Risk*, concluded that:

The proportion of students taking a general program of study increased from 12% in 1964 to 42% in 1979

Only 31% of recent high school graduates completed Algebra I; only 6% completed calculus

Twenty-five percent of the credits earned by general track high school students were in physical and health education, work experience outside the school, remedial English and mathematics, and personal service and development courses, such as training for adulthood and marriage

Thirty States required only 1 year of mathematics, and 36 required only 1 year of science to graduate

Courses in driver education and cooking carried as much credit toward graduation as courses in science and mathematics

Fewer than one-third of U.S. high schools offered physics taught by qualified teachers. (pp. 18-21)

Although there had been an overall reduction in the proportion of students taking college preparatory mathematics and science courses during the latter part of the 1960s, *A Nation at Risk* (1983) failed to acknowledge that 1) most of the statistics



cited also applied to public schools in the early 1960s when student achievement had been much higher and 2) the trend had begun to reverse by the mid-1970s.

Between 1972 and 1980, although schools offered more advanced placement courses in science, there was a slight decrease in the amount of science taken by students in general programs of study during this period, down from 3.71 to 3.46 semesters. High socio-economic students in academic programs, however, took more science in 1980 than in 1972. West, Diodato, and Sandberg (1984) reported that the proportion of public high schools that offered one or more science courses increased from 89% in 1972-1973 to 99.7% in 1981-1982. The authors also found that enrollment in science classes increased from 6,119,000 to 8,278,000 during this same period. In terms of enrollment, these figures represented 51% of the total school enrollment in 1971-72 versus 65% of the total high school enrollment in 1981-1982. By the beginning of the 1980s--prior to the publication of *A Nation at Risk* (1983)--a larger percentage of students were taking science courses than at the start of the previous decade.

Throughout the 1970s, the course-taking pattern in mathematics was similar to science. Students, regardless of their program of study, took significantly more, not less, mathematics (West, Diodato, and Sandberg, 1984). There were, however, differences in course taking patterns according to race/ethnic background. By 1980

Black, Hispanic, and Asian students took more mathematics courses than White students.

On the basis of student course-taking patterns during the 1970s, student achievement in mathematics and science should have at least remained stable, and more likely should have improved based upon the student course-taking patterns. However, the actual trends in science achievement, as shown previously in Chapter 3, showed a sharp decline between 1970 and 1981. This decline cannot reasonably be attributed to changes in course-taking patterns in science and mathematics.

During the 1980s, as a result of the national "Excellence" movement, students took even more science and mathematics courses. Between 1982 and 1987, the percentage of students taking science courses increased from 95% to 99%. The percentage of students taking biology increased from 75% to 90%; chemistry increased from 31% to 45%; and the percentage of students taking physics increased from 14% to 23% (Westat Inc., 1988). Moreover, the increase in the average number of science and mathematics courses taken by high school students exceeded the increases in other academic courses (National Science Board, 1989).

The increase in science and mathematics enrollments during the 1980s was reflected in somewhat improved science achievement scores. However, the National Science Board (1989) reported that these increases were slight and did not make up for previous declines in achievement scores. As illustrated in Table 1, the science



proficiency scores for all groups of student groups--male, female, White, Black, and Hispanic--were lower in 1986 than in 1970.

The decline in student science achievement during the 1970s cannot be explained by the changes in course-taking patterns. However, the slight improvement in aggregate SAT-M scores in 1986 may have been due to upturns in enrollment in science and mathematics courses, as well as other educational reforms (National Science Board, 1989). The question that still remains to be answered is why did not the "Excellence" reforms produce larger gains in science achievement?

### **Values**

During the 1970s increasing numbers of students came to place more value on making money (Rock et al., 1985). Fewer students in 1980 compared to a decade earlier reported that working to correct social and economic inequalities was an important goal. Rock et al. concluded that the environmental and social consciousness of the 1960s had been replaced by self-interest in job success and security. By 1980 the percentage of students desiring clerical jobs had declined, as greater numbers of students sought managerial and technical occupations.

Between 1972 and 1980, students increased in self-esteem, but became less confident in their ability to control their futures. By 1980 students were more interested in freedom to make their own decisions, job security and permanence, and a good income. Between 1972 and 1980, there was no change in the percentage of students who planned to go on to post-secondary education, but by 1980 a greater

percentage of high school students believed that they had the ability to complete college.

### **Family Background**

The socio-economic status, level of education, attitudes, and aspirations of parents help to shape the attitudes of their children. Parents in 1980 were on the average more educated than parents in 1972 and they tended to have higher aspirations for their children. This trend was consistent across all ethnic groups except Hispanics (West, Miller, & Diodato, 1985).

The occupations of fathers shifted toward more managerial and proprietor positions. The major change in parental occupation during the 1970s was for mothers. Between 1972 and 1980, the proportion of full time homemakers declined from 55.2 to 15.1%, as mothers moved from the home to the work place.

When teachers were asked what they thought were the principal causes of student difficulty in school, their most frequent response was family-related problems (*Education Indicators*, 1989). Teachers (51%) said that latchkey children, i.e. children who were left on their own after school, were a major factor. Teachers (44%) blamed family poverty. The most common school-related factors cited as causes of student difficulty were automatic promotion (44%) and the inability of teachers to adapt to the individual needs of the learner (43%). One possible cause of the



inability of teachers to adapt to the individual needs of the learner was that the needs were changing.

The students' attitudes toward school were shared by their parents. In 1969, 45% of people responding to *The 13th Annual Gallup Poll of the Public's Attitude toward the Public Schools* (Phi Delta Kappan, 1981) favored raising taxes for public education. By 1981 only 30% supported higher taxes for education.

### Conclusions

Rock et al. (1985) concluded that shifts in population demographics played only a minor role in declining test scores. Instead, they found that changes in student behaviors and school characteristics played major roles in score declines. Further, they concluded that student school behaviors were more important than school characteristics in the decline of the SAT-M score. The results show that there was very little change in the general perception of teacher quality, but there was a definite attitudinal change that schools were not placing enough emphasis on academics.

The Metropolitan Survey (1988) concluded that the majority of both teachers and students agreed that teachers knew their subject matter and how to teach so that lessons were clear and easy to understand. Furthermore, the survey found that teachers were enthusiastic for the subjects and maintained discipline.

The conclusions, based upon the results of Chapters 4 and 5, are that changes in the school climate and changes in student attitudes and behaviors seem to be the primary factor related to declining student achievement. The teachers are better; the

curricula have been improved; educational technology has changed the classroom forever.

Moreover, by the mid-1970s alarms began to sound that student achievement in science, mathematics, and literacy were declining so that schools began a move toward "Back to Basics." As shown in this chapter, academic students took more science and mathematics, during the 1970s. Throughout the 1980s schools reduced the number of electives and increased the number of required core courses. At the same time schools raised standards for teachers.

Yet, all of these educational enhancements have not resulted in the expected gains in student science achievement. Instead, the improvements in teachers, curricula, methods of instruction, and standards have been eclipsed by other changes. In the next chapter, societal changes responsible for altering the school goals and influencing student attitudes and behaviors are discussed.



## **CHAPTER 6**

### **SOCIETAL INFLUENCES ON SCHOOLS IN THE POST-SPUTNIK YEARS: 1958-1990**

American society since its inception has looked to its schools to promote the values of the community. Consequently, the community has influenced the goals of its schools to reflect these values. As community values have changed over time, the community has shifted the goals of its schools. This view of American education was expressed by Coombs (1985) who said that school systems are shaped by environmental forces.

Prior to World War II, American culture had changed relatively slowly. The size of the country, its rural character, the traditional values and religious convictions of American families, and the ties to community all acted to dampen change. After World War II, however, Americans became more mobile; there was a large shift in population to the cities, and the development of television brought new ideas into American homes. These factors made possible the rapid changes in society that occurred after 1960.

Federal involvement in public education, major social movements, and changes in the family were all parts of the societal changes after 1960. In the following sections, the declines in science achievement during the 1960 and 1970s and the

failure of the educational reforms of the 1980s to restore achievement to previous levels are related to societal changes which altered the goals of public education.

### **Federal Involvement in Public Education**

Between the years 1957 and 1990, the Federal Government has shifted the focus of public education four times. The first shift occurred after World War II. America rushed to complete a national program begun during the Eisenhower administration to improve the science programs in public schools. The second shift occurred during the Johnson administration in response to court-mandates of the 1950s and the resulting Civil Rights Movement of the 1960s. The Federal Government intervened a third time in public education beginning in the latter part of the 1960s and into the 1970s to mandate handicapped education and mainstreaming. The fourth shift in the focus of public education was initiated during the Reagan Administration in response to growing national concern that there were again serious deficiencies in the education system, especially in the areas of science and mathematics. The following sections describe these four distinct periods of federal involvement in U.S. public education since 1957 and the effects that they have had on the educational goals.

#### **The Eisenhower Administration**

The first federal intervention in public education was during the Eisenhower period. In 1953, President Eisenhower began to develop a policy of federal involvement in education when he submitted a proposal to Congress to establish the



Department of Health, Education, and Welfare. However, when the Soviet Union successfully placed the first satellite in Earth orbit, the Federal Government entered upon a new level of involvement in public education.

*National Defense Education Act (NDEA)*. In 1958, President Eisenhower signed into law the NDEA. The motivation for the NDEA, as indicated by the title, was to strengthen national defense by improving selected subject areas such as science education in public schools.

The NDEA provided federal money to develop new curricula and instructional strategies in science, mathematics, and foreign languages. The NDEA also provided funds for teacher training programs in these areas. By 1963 approximately 21,000 teachers attended summer institutes in science, mathematics, and foreign languages (Shymansky, 1983).

In 1959, the first year that the National Defense Education Act was implemented, 23 million dollars were expended to strengthen science, mathematics, and foreign language instruction by upgrading demonstration equipment and laboratories and by improving public school teachers, curriculum, and methods of instruction. In the second year of the act, 105.5 million was expended; in 1961, 94.8 million was spent, and in 1962, 99.7 million was used to fund projects (U.S. Office of Education, 1969). Between 1958 and 1968, the NDEA supported 45,829 graduate fellows at a cost of over a third of a billion dollars (National Research Council, 1977).

Originally, the NDEA was to last only 4 years, but was extended in 1961, 1963, and 1964 (Commager, 1973). By 1968 more than 300 million dollars had been

allocated to provide 26,828 graduate fellowships for advanced study (Commission on Human Resources, 1977).

As a result of the NDEA, the quality of science teachers was improved, technology was incorporated into science courses, and library resources were upgraded. NDEA did improve student achievement and interest in science, as reflected in higher test scores and greater numbers of students enrolled in science and mathematics courses during the early 1960s (Altbach, 1985).

*National Science Foundation (NSF)*. Federal efforts to improve science education did pre-date the NDEA. NSF was established in 1950 as an independent federal agency. The NSF mandate was "to develop a national policy for the promotion of basic research and education in the sciences" (Krieghbaum and Rawson, 1969). (p. 4) In 1954, the NSF conducted its first summer workshops for high school teachers. The total amount of the funds expended was ten thousand dollars. However, the NSF budget rapidly grew. Between 1954 and 1965, the expenditures for summer programs was approximately 165 million dollars (Krieghbaum and Rawson, 1969) and dozens of new science programs were developed for grades K-12 with funding from the National Science Foundation (Shymansky, 1983).

The summer institutes were gradually expanded. Institutes were developed to update, upgrade, reorient, and advance the training of teachers in science and mathematics. NSF was used to reorient teachers to the PSSC and to the BSCS



curricular projects. Eventually, the summer institutes were supplemented with in-service and non-summer institutes.

As mentioned previously, NSF was established as an independent agency. This provision allowed it to operate with operate outside of the political arena. By making NSF an independent agency, its founders hoped to eliminate the possibility that the Federal Government could use the agency to exert its influence on public education.

Clearly during this period, excellence in science and mathematics were primary goals of public schools. To meet these goals, high-ability students were channeled into college preparatory science courses and students who could not handle the work were placed in general or vocational tracks. One of the characteristics of this period was the lack of electives open to students in college tracks. With few exceptions, all college-bound students took a general,earth, or physical science; biology; chemistry; geometry; and 2 years of algebra. During this time academic standards, rather than the development of a student's self-concept, were of primary importance. Student rights had not yet been "discovered."

### **The Johnson Administration**

By 1964 American concerns had shifted from the cosmos to towns and cities on Earth. The country was faced with increased pollution of its air, land, lakes, and rivers; and not even the vast oceans were safe from the effects of pollution. Prior to the 1960s, science had been viewed as the solution to all of our country's problems. Scientific breakthroughs and new technology promised new sources of cheap energy,

the elimination of poverty, and a ever better standard of living. During the 1960s, this attitude changed and the public increasingly came to view science and technology as being responsible for the factories and chemicals that polluted the environment. The publication of Rachel Carson's *Silent Spring* in 1962 was quickly followed by the Environmental movement, the passage of the Clean Air and Water Acts, and the creation of the Environmental Protection Agency.

The national concern of the 1960s for its cities and towns were not limited to the environment. Events in the South confronted all the American people, as they witnessed on their television sets the oppression of Black citizens. They watched Civil Rights demonstrators being beaten by police for demanding their Constitutional rights. The national outcry that followed led to the passage of the Civil Rights Act of 1964 and the Elementary and the Secondary Education Act (ESEA) of 1965. The aim of the Elementary and Secondary Education Act of 1965: PL 89-10 (ESEA) was given as:

The Congress hereby declares it to be the policy of the United States to provide financial assistance to local educational agencies serving areas with concentrations of children from low income families to expand and improve their educational programs by means which contribute particularly to meeting the special educational needs of educationally deprived children (PL 89-10, Section 201)

Specifically, ESEA provided for:

- 1) Three-year grant programs to local educational agencies serving children in regions with high concentrations of low-income families
- 2) Grants to purchase library resources and textbooks in public and private non-profit schools



- 3) The establishment of model schools, community centers, and pilot programs
- 4) Grants to college, universities, organizations, and individuals for educational research, surveys, and demonstrations
- 5) The improvement of state departments of education by grants for research, planning, and personnel development

In 1966, 1.1 billion dollars was appropriated for ESEA, increasing to 1.8 billion by 1971, signalling a new wave of federal involvement in public education (Sidebotham, 1989). National defense was no longer the issue; instead, the nation turned to mount a "War on Poverty" with the aim to establish President Johnson's "Great Society."

Whereas the Eisenhower legislation had targeted the best students in science, the Johnson focus was disadvantaged students. Consequently, funds were shifted from science to remedial reading and language arts. This new direction was recognized by Ravitch (1983), who maintained that the NDEA educational goals to produce high science achievement were replaced by new goals to correct past racial injustice. Beginning with ESEA the Federal Government began to strengthen its involvement in education by requiring that schools comply with federal guidelines to receive funding.

### **The Nixon/Ford/Carter Administrations**

By 1968 the United States was on the verge of placing a man on the moon. Yet, the problems of poverty, racial injustice, and pollution had not been solved at home. Pictures of Earth from orbiting space craft only strengthened the public

conviction that the United States needed to spend more money to solve the immediate social problems that had led to mass rioting and social upheavals. For these reasons, the goals of public education continued to shift from high science achievement to social remedies for more than two centuries of government-supported racism.

The trend of federal involvement in public education continued with the passage of the Bilingual Education Act of 1968, which became Title VII of ESEA. The law was re-authorized in 1974 and 1978. Title VII was created to assist "children of limited English-speaking ability," which was specified to mean children who came from homes in which the primary language was not English. States were allocated funds based on their concentrations of bilingual students. This act provided programs for bilingual education, historical and cultural education, early childhood education, adult education, and dropout prevention. Beginning under ESEA and continuing with the Bilingual Education Act, federal funds were allocated for remedial reading and language arts instead of science and mathematics (Sidebotham, 1989). Thus, the shift from science and mathematics continued.

In 1965-66 approximately 18% of the curriculum and instructional money was directed toward science education (Statistical Report, FY 1967 Title I/Year II); in 1967-68, this proportion dropped to 12%; by 1972-73, 1% of the instructional funds were directed to science and mathematics (Statistical Report, FY 1968 Title I/Year



II); For the 1971-72 school year, 12% of all public school students were enrolled in Title I remedial programs; by 1976 20% were enrolled (Sidebothom, 1989).

The American educational pendulum had been set into motion after World War II. From the early 1950s until about 1964, the pendulum gathered speed in the direction of high standards of science achievement. However, the rise of the Civil Rights movement caused the pendulum to swing the other way. The ascent of the equity in education replaced scientific excellence as the educational goal of the 1960s.

During the 1970s, the equity movement in education continued. The passage of the Education for all Handicapped Children Act: Public Law 94-142, required schools to mainstream handicapped students into regular classes. This act shifted federal funds for education to special education. Public schools were directed to establish programs to ensure educational equity for mentally, emotionally, and physically handicapped students. Furthermore, educational equity meant that such students must be mainstreamed whenever possible. In order to mainstream such students, schools had to develop specialized programs to assist these students in succeeding in regular classroom environments.

Between the passage of the NDEA in 1958 and P.L. 94-142 in 1974, the nature of the federal involvement in education had grown significantly and had evolved from simply providing funds to prescribing programs that must be implemented to receive funding. Through the purse string, the Federal Government had become the guiding influence in determining the goals of public schools. The potential of an increasing federal role in education had been a serious concern of

President Eisenhower. According to Ravitch (1983), it was the concern for national security that finally decided the issue. The urgent need to develop the best young minds in science and mathematics in the post World War II era outweighed the potential threat of federal influence in public education.

### **The Reagan Administration**

The fourth period of federal influence in public education was during the Reagan years. President Reagan disavowed the increased federal involvement in public education, particularly in terms of federal financial support for public education. In his view, the responsibility for education rested squarely with the individual states and Reagan had campaigned to dismember the Department of Education (DOE). Once in office, however, Congressional opposition forced him to abandon this plan. Nevertheless, he appointed William Bennett, a former supporter of dissolving the Department, as Secretary of Education. Under Bennett's leadership, the staff were reduced from 7,400 to 5,000, programs were reduced or eliminated, and the DOE budget was slashed (Clark, 1986).

The Reagan government called upon the individual states, cities, towns, and even private companies to shoulder more of the responsibility and cost for public education. On August 13, 1981 President Reagan signed into law the Educational Consolidation and Improvement Act of 1981, which reversed a trend of steadily increasing funding for public education. Between 1960 and 1964 federal educational funding nearly doubled to 3 billion dollars; by 1966 it doubled again; and by 1972 it



doubled again to 12 billion dollars (Ornstein, 1985). By 1980 the education budget had again more than doubled to \$25 billion dollars.

In 1982, the first year of Reagan's presidency, the federal expenditures for education dropped 5%, compared to a 10.2% increase in each of the previous 6 years (Ornstein, 1985). During the next 6 years, the education budget increased, but at a much lower rate than in the previous two decades. The state-oriented policy was implemented by requiring each state's governor to appoint an advisory committee, comprised of students in public and private elementary and secondary schools, teachers, parents of elementary and secondary students, members of local school boards, representatives of higher education, and state legislators (PL 97-35, Sec 564).

At the same time that the Reagan government began to withdraw funds for public schools, it called for a return to excellence in education, while arguing simultaneously that increased funding was not the solution to the problem (Altbach, 1985). The educational goals were again being shifted, but the focus was unclear. Whereas, during the Eisenhower administration the funding and the educational goals were aligned, "The focus for schooling during this time became confused due to the incompatibility of public statements supporting academic excellence while the majority of federal funds available for schooling continued to go toward the disadvantaged student with subject matter emphasis on some aspect of reading/language arts and mathematics" (Sidebothom, 1989). (p. 117)

The emphasis on the disadvantaged student in public education during the 1970s was evident in the pattern of science achievement scores. As was shown in

Chapter 3, the SAT-M scores of Black, Puerto Rican, Mexican-American, and American Indians generally increased between 1976 and 1989. White students were the only student group whose scores were lower in 1989 than in 1976. The NAEP tests showed a similar pattern with other student groups making larger improvements, than White students. Schools in the early 1960s had raised student science achievement when that was the primary goal of education. And during the 1970s, when compensatory education became the dominant educational goal, schools significantly improved the science performance of disadvantaged students. What the schools had failed to do was to simultaneously satisfy both of these goals.

The effort to make schools more equitable had also added another goal for public education. In addition to improving the achievement of disadvantaged students and science and mathematics achievement for all students, schools were directed to reduce the numbers of student dropouts. During the Reagan administration, dropout prevention and drug education gained increased attention with the consequence that science and mathematics got an even smaller share of the reduced school budget. The now famous phrase "Just say no to drugs" could have been applied to funding for science and mathematics!

Whether the goals of "Excellence" and "Equity" are compatible, is still unclear. Sidebotham argued that these successive periods were in conflict and not really compatible, in that each established "programmatic thrusts" that were at odds with each other. It may simply be that the social equity goals have been implemented in such a way to lessen science achievement. What is clear is that the changing of the



educational goals by the Federal Government has influenced the emphasis that schools have placed on science achievement, which in turn has resulted in different trend in science achievement for the various student groups.

The notion that the involvement of the Federal Government in education has had deleterious effects on achievement is shared by other authors. Kaestle and Smith (1982) cite the involvement of the Federal Government in education as a cause of, and not a solution to, the decline in public education." They state that:

. . .many professional educators and analysts. . . view the involvement of the Federal Government as a major cause of a general decline in the quality of American public schooling. They have seen federal programs at the periphery as taking resources and attention away from the central tasks of the school. (p. 406)

### **Social Movements**

Federal legislation was not the only factor that has changed the goals of public education over the last three decades. Societal changes that have altered the attitudes of the public, parents, and students toward public education have also influenced schools. Since the 1960s, much of what Americans believe and take for granted--our cultural heritage--has come into question, altering the very character of our society. American attitudes toward sex, authority, religion, violence, and education, and schools have undergone a cultural revolution.

The federal legislation that altered the role of public education did not operate in a social vacuum. Rather, much of this legislation was in response to changes in American political and social attitudes. The social movements during the

last three decades have contributed to the changing role of public education in the United States.

During the 1960s Americans began to question their government and public institutions. The Civil Rights and Vietnam protests were waged not only in the streets but in the high schools, colleges, and universities of the nation. An effect of the politization of schools was that educational institutions lost the separateness that had insulated them from society.

As Allan Bloom recounts in the book *The Closing of the American Mind* (1988), universities turned over the decisions about values to the Zeitgeist, the populum. The protest movements of the 60s became convinced that the universities and schools were "ivory towers"--distant and elite--and therefore immoral. According to Bloom, universities and schools no longer stand outside public opinion. Instead, academic freedom has been subsumed in the quest to eliminate racism, elitism, and feminism. Bloom states that whereas philosophy and natural science were once considered the avenues to discover truth about reality and the universe, popular opinion in the United States has laid claim to truth in which passion and commitment have equal footing with reason and science.

According to Bloom, the effect of this attack on education was to level the distinction between educated and uneducated, producing the "homogenized man." The protests of the 60s attacked education programs that catered to the most able students as elitist. Where only a few years previous, school tracking of students by ability was used to develop science achievement, tracking came to be seen as a form



of discrimination that relegated less able students to less able teachers and inferior curriculum. As the social disorders of the 1960s entered the classroom, to a large extent, control of educational institutions in the United States was transferred from educators to students and to the public. This pattern has continued throughout the 1970s and into the 1980s. The call for parental involvement in all aspects of schooling and the movement toward schools of choice are outgrowths of this mentality. A direct effect of the shift in control of schools has been a reduction in the ability of schools to direct the education process.

The extent to which the control of schools has been shifted away from the educators is readily apparent when one compares the reforms of the 1980s to the NDEA programs of the 60s. In the late 1950s, schools were criticized for not providing quality educations, especially in science and mathematics. The educational solution was to provide more funds to schools to develop science programs and to provide funds for teachers to improve their knowledge and develop their skills.

In the 1980s, schools were once again criticized for not providing a quality education. However, by this time schools had lost their separateness from society. Unlike the NDEA reforms, which looked to schools and teachers to solve the educational problems, the report *A-Nation-at-Risk* aimed its criticisms directly at schools and teachers as having failed in their duty to provide quality education. Instead, of looking to the educators for solutions, school boards, local and state governments, and local pressure groups assumed major roles in reforming schools. Every element of schooling from textbook selection, to curriculum, to teacher

training, to testing came under public scrutiny. This change of control from educators to the general public had assumed a major role in directing the curricula.

### **The American Family**

The social revolution of the sixties was mirrored in the revolution in nature of the American family. Prior to 1960, the typical American household consisted of a working husband who was the undisputed head of the household, a wife who was a full time mother and housekeeper, and several children. The typical family settled in the same community in which they grew up, spending their lives among family members and life-long friends. Community life and church membership played important roles in family life. Churches reinforced the moral training for children and promoted the authority of parents. Family, peer, religious, and other societal groups all supported the family and strongly discouraged divorce and premarital sexual relationships.

By 1988 the typical American family was quite different. For example, the percentage of persons who reported attending churches or synagogues decreased from 47% in 1960 to 42% in 1988. At the same time, the percent of people expressing no religious preference had increased from 3% to 9% (*Statistical Abstracts*, 1972, 1990).

The decline of religious influence was accompanied by changes in marriage and divorce rates. According to the *Statistical Abstracts of the United States* (1972), 76.2% of the males and 71% of the females 18-years-old and older were married in



1960. By 1988, the percentage of married males had dropped to 68% and the percentage of married females had dropped to 62.3% (*Statistical Abstracts*, 1990).

As marriage rates declined, the divorce rates increased. In 1960, the percentage of over-18 males who were divorced was 2.1%; for females the percentage was 2.9%. By 1988 the percentage of divorced males and females had more than tripled to 7.1% and 9.2%, respectively. In terms of the percentage of marriages that eventually fail, 50% of the American marriages of the 1980s ended in divorce. In absolute numbers, there were 393,000 divorces in 1960, compared to 1,183,000 divorces in 1988.

As a result of the increased frequency of divorces, growing numbers of children are raised by single parents or by parents who have remarried. Moreover, increasing numbers of unmarried women had children during this period. In 1960, unmarried women accounted for only 5% of all births. By 1970, the number had doubled to 10.7%; and by 1988, unmarried women accounted for 24.5% of all births. This percentage represents 933,000 infants born to unmarried women.

The extent of the change in American attitudes toward extramarital births are evident in the title changes in *Statistical Abstracts* between 1972 and 1990. In the 1972 edition, the table was entitled "Illegitimate Live Birth:" in the 1990 edition, the title had been changed to "Births to Unmarried Women." Just between 1980 and 1988, the percentage of children living with a single mother increased from 0.8% to 6.8%. For Black children the percentages were much greater, so that in 1990 28.2% of all Black children lived with a single mother. As more and more mothers have

entered the work force, their "latchkey" children have to spend much of their time alone at home or in after-school or day-care programs.

As the family structure changed in recent decades, so too did the behaviors of the children. Between 1970 and 1986, the suicide rate for students between the ages of 10 and 14 nearly tripled from 0.6% to 1.5%. During the same period, the suicide rate for teenagers aged 15 to 19 years increased from 5.9% to 10.2%. Another change in teenage behavior involves sexual promiscuity. In 1973, women 19-years or younger had a total of 244,000 abortions; by 1985 the percentage had increased to 416,000.

The changes in society and the family are reflected in the increasing crime rates. Between 1960 and 1988 violent crimes such as homicide increased by 68%, forcible rapes increased by 376%. During the same period, robbery increased by 368% and aggravated assault rose by 595%. Nonviolent crimes showed similar trends. Burglary increased by 641%, larceny rose by more than 2500%, and motor vehicle thefts increased by 787%.

The increased crime rates have similarly influenced schools. During the 1990s, terms such as a "safe learning environment" have become common when applied to public schools. In urban schools, armed security guards are a common occurrence. One high school principal in New Jersey, who carried a baseball bat in the halls and



locked the fire exits to keep out drug dealers, became a national celebrity and the subject of a major motion picture.

### **Conclusions**

Federal involvement in public education is one factor that has altered school goals. Since 1957 the Federal Government has become increasingly active in setting the goals of public education. The Federal Government has used schools as vehicles to correct problems of national concern. Ravitch (1983) cited a series of examples of federal educational responses designed to address social problems. These examples included racial segregation/integration, Hispanic immigration/bilingual education, poverty/compensatory education, and unemployment/job training. According to Altbach (1985):

Schools have been expected not only to teach children and provide the basic skills needed by a complex technological society but also to solve the dilemma of racial discrimination, to provide opportunities for women and minorities, to socialize generations of immigrants and to bend to changing social policies, such as church-state relations, and "sex education." (p. 14)

As the Federal Government shifted the focus of education, goals were changed for schools. This changing of goals led to confusion among educators as to what were they really supposed to teach to whom. Was their purpose to provide academic rigor and the best science educations for their students? Or were they supposed to help each student to reach his or her individual potential. In simpler times, an "A" was an "A"--a grade achieved by scoring above some standard such as being in the top 10% of the scores. However, standards such as these came into question as schools

were told that all students needed to succeed. Social promotion, i.e., mandatory promotion to the next grade regardless of achievement, was nearly unheard of prior to 1960. Yet, by 1980 in many school districts across the country, social promotion was not only accepted, but required. Teachers were told that holding a child back was tantamount to child abuse; that such practices permanently damage the student's self-esteem (Lange, personal communication 1989).

A second influence on school goals has been changes in the American society. Today's schools have the distinction of being one of the few public institutions that are directed, to a large extent, by their clients. The turmoil of the 1960s stripped away the last vestige of academic autonomy. Just as the shiny armor of science had been tarnished by the events of the 1960s and 1970s, the white cloak of "Truth" had been torn from educational institutions. The loss of academic autonomy made schools more vulnerable to changes in the winds of societal issues.

A third influence on school goals, related to societal changes, is changes in the American family. The significant role that parents and students now play in the areas of curriculum and academic standards has presented schools with a new set of problems. Because the characteristics of parents and children have changed significantly in recent decades as the structure of the American family has radically changed, schools have been forced to accommodate the rapidly changing needs of parents and students.

Prior to the mid-1960s students were given very little choice in what courses they took. Academic standards were determined primarily by the teacher, and



students had to meet these standards. By 1990 in many public schools in the United States, academic standards are determined to a great extent by parents and students. In such schools, the failure of a student is the failure of the school. Consequently, teachers experience pressure not to make their schools fail.

Because academic standards are now closely linked to student characteristics in today's schools, any negative changes in student characteristics, such as lower motivation, can lead toward lower academic standards. In much the same way, changes in student values, such as occurred during the 1970s, that placed less worth on education would have a similar detrimental effect on academic standards.

Altbach maintained that the present crisis is the result of past policies and a "long-standing American confusion concerning the role of the schools in society." (p. 13) Furthermore, the author noted that in none of the recent periods were the programmatic thrusts initiated by the educational community. Rather in each case, the programs were thrust upon schools and they in turn were forced to react to federal pressures.

The poor showing of students in the United States on the 1986 International Assessment of Educational progress led Lapointe, Meade, and Phillips (1989) to suggest that factors other than teachers and curricula might be responsible for the differences in student performance among the different countries. The authors attributed the performance disparities to differences in the value that societies place on science and mathematics education, to differences in attitudes of parents and students, and to differences in student motivation and willingness to learn in



particular. In fact, in the authors found that "there is little consistency in the relationship between types of classroom activities and achievement." (p. 80)

As schools have become inexorably entwined with social concerns over the last 30 years, the goals of schools have been shifted at very short intervals. The changing goals of public education are discussed in the 1984 report, *A Trend Study of High School Offerings and Enrollments: 1972-73 and 1981-82* (West, Diodato, & Sandberg) (p. 1). The authors reflect that "Over the past 15 years, secondary schools have served both as a laboratory for new curricula and instructional ideas, and as a battleground for conflicts over the goals of secondary school education."

As has been discussed, during the Eisenhower presidency, the Soviet threat to national security was countered by enlisting schools to turn out the scientist and technicians. During the 1960s, schools were chosen as vehicles to redress social inequalities and to reduce poverty. During the 1970s, schools were legislated to mainstream handicapped and to provide training for poor students. The charge for schools in the 1990s is to continue programs ensuring equal access, but to again focus on excellence in science and mathematics.

The problem is not that schools have been enlisted to help correct social inequities. Nor is the problem the fact that schools have been asked to assume an expanded number of responsibilities. The problem is that the shifts in educational thrusts in response to societal and federal imperatives have altered previous school goals, replacing them with new seemingly discrepant goals. This fact will be demonstrated in the next chapter in which the changes in student science



achievement are re-analyzed in the context of the changing societal pressures exerted on the public school system.

## **CHAPTER 7**

### **FACTORS RELATED TO THE DECLINES IN SCIENCE ACHIEVEMENT--AN ALTERNATIVE HYPOTHESIS**

In this chapter the changes in science achievement are re-examined within a historical context. The purpose of this analysis is to demonstrate that changes in the SAT-M and the NAEP scores since the 1960s seem to be related to changes in changes in the school goals, and to changes in student motivation and parental attitudes toward education. An alternative hypothesis is then presented to explain possible causes for the declines in science achievement after 1963, as well as the failure of the educational reforms of the 1980s to restore science achievement to the 1963 level.

#### **Trends in Science Achievement within the Context of Societal Influences**

The dramatic changes in the SAT after 1963 can only be explained in relation to the equally dramatic changes in American society at this time. Figure 16 shows the SAT-M in a historical context. In the figure the SAT-M trend is superimposed



upon a background of societal forces that helped to alter school goals. The first agent of change was the National Defense Education Act (NDEA).

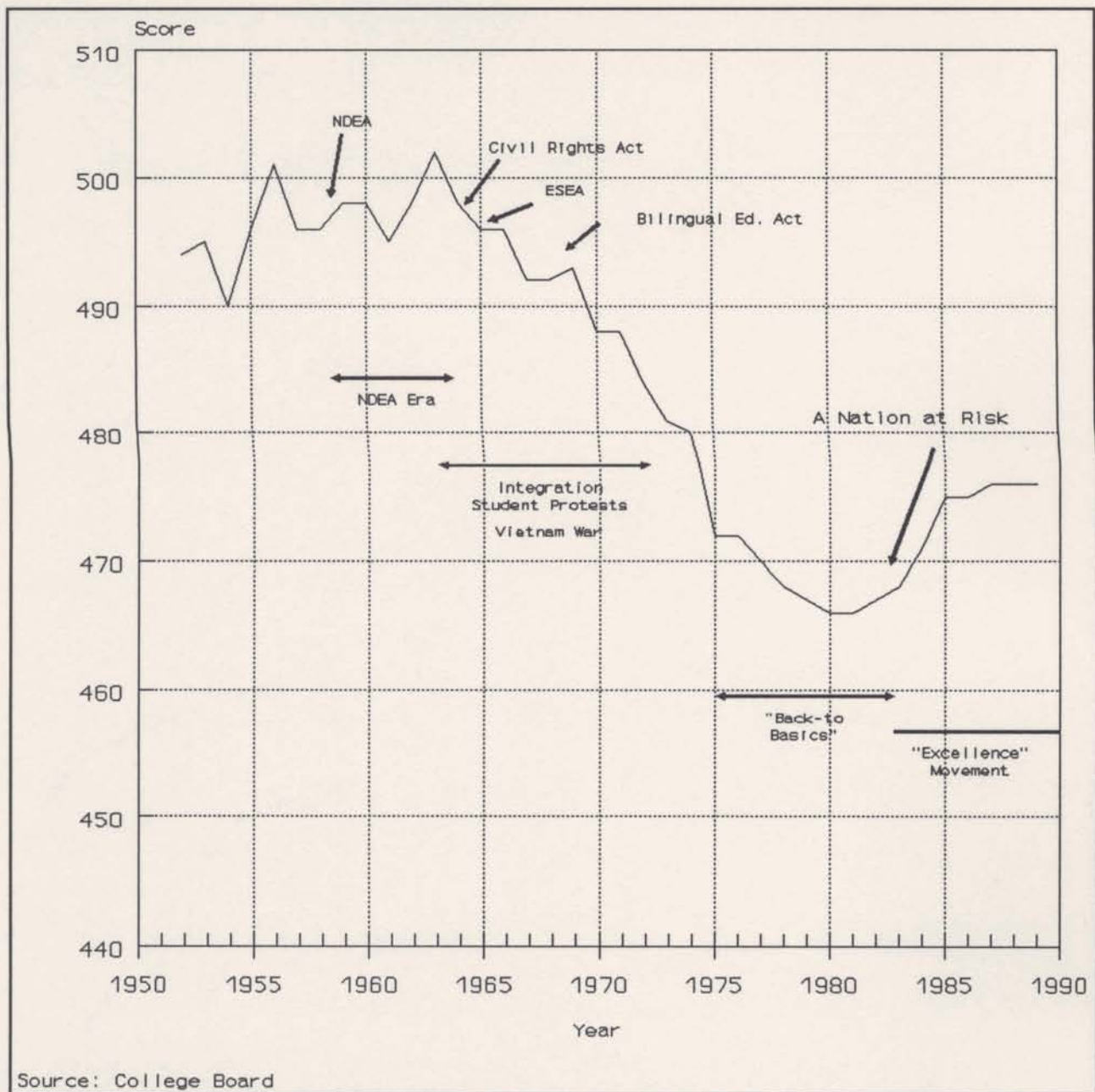
### **The NDEA**

The NDEA reforms were passed in 1958, and 5 years later SAT-M scores reached their all time high of 502. Since the SAT test taking population was very stable between 1958, it is very likely that the increases in the SAT-M scores during this period were the result of the NDEA reforms (College Entrance Examination Board, 1977).

If the student population had remained stable after 1963, then based on the research on trends in teacher quality and the effectiveness of the innovative science curricula, the SAT-M scores should have continued to increase after 1963. If we assume a conservative increase in the SAT-M of only 5 points per decade, then the average SAT-M should have been approximately 515 in 1990, as opposed to the actual average of 491.

### **1960s: A Decade of Social Unrest**

However, the student population did not remain stable in the decades following the integration of public schools. As Figure 16 shows, the integration of schools in the mid-1960s coincided with declining SAT-M scores with the greatest declines occurring between 1967 and 1972. The College Entrance Examination Board estimated that Black students accounted for only 1% of the SAT-M test-taking population in 1963. By 1972 the percentage of Black students taking the SAT had



**Figure 16.** The SAT-M Trend in the Context of Societal Changes

increased to 8.5%. Prior to the integration of public schools in the mid-1960s, Black participation in the SAT was extremely low. Since most colleges did not accept Black

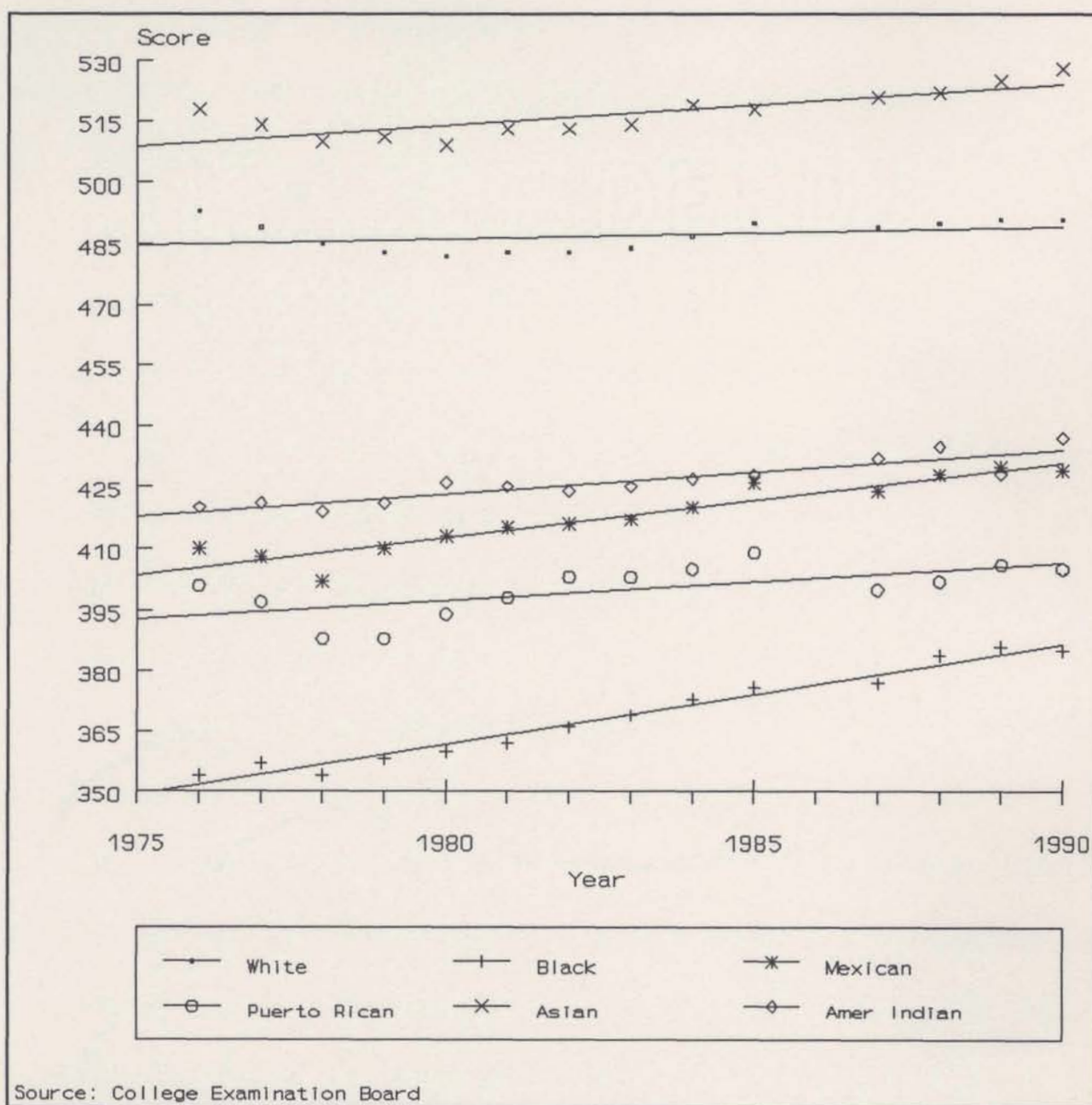


students, there was little reason for Black students enrolled in Black high schools to take, or to be encouraged to take, the SATs.

When public schools and colleges were integrated, the increased numbers of Black students taking the SAT exams lowered the average score (College Entrance Examination Board, 1977; also see Table 12). Referring to Figure 17, it can be seen that the SAT-M scores of Black students average approximately 100 points below that of White students. For this reason, increased numbers of Black students taking the SATs during the 1960s tended to lower the aggregate SAT-M average.

Integration, however, was not the only demographic change during this period. Between 1960 and 1970, the total number of students taking the SATs increased dramatically, tripling between 1960 and 1970. There were two reasons for this increase. First, the growth of the state community college systems meant that a greater proportion of the enlarged student body would be applying to college and therefore taking the SAT tests. Second, the American economy was strong and there was an unprecedented emphasis on post-secondary education. Because a wider range of students began to take the test, the average SAT-M score declined.

A third factor that contributed to the decline of the SAT-M during the 1960s was the increased percentages of females taking the SAT. Since the average SAT-M score for females is approximately 45 points lower than for males (Figure 12), an



**Figure 17. Racial/Ethnic Trends in the SAT-M: 1976-1990**

increase in the percentage of females had the effect of lowering the aggregate SAT-M average.

A fourth factor that led to the declining test scores during the 1960s was a change in school goals. This change emphasized reduction of the numbers of



students who dropped out of high school. Whereas, in 1950 the drop out rate was 42%, by 1970 the dropout rate had decreased to about 23% (*Digest of Educational Statistics*, 1967; *Digest of Education Statistics*, 1989). As a consequence of more students completing high school, a broader range of the student body took the SAT tests, which in turn lowered the aggregated scores.

A fifth reason why the scores declined was the turmoil of period. The Vietnam War, school integration, the Civil Rights movement, the environmental movement, and various protests surrounding those movements all may have served to distract teachers and students from the teaching and learning of science. The societal emphasis on social issues and the concomitant educational preoccupation with individual feelings may have led to the affective study of the social sciences and humanities to the detriment of effective study of cognitively oriented sciences.

The combined effects of a broader range of SAT-M test-takers, increased numbers of Black and female students, and the political and social concerns and turmoil of the 1960s all conspired to lower the aggregate SAT-M scores. The College Board (1977) estimated that two-thirds to three-fourths of the drop in SAT-M scores between 1963 and 1970 was due to demographic changes. The remaining 25% of the SAT-M drop was probably due to the social and political upheavals of the 1960s.

### **1970s: The Bottom Falls out of the SAT-M Scores**

In 1972 integration of public schools was essentially complete. By this time 89% of Black students in the South and 98% of Black students in the North and



West attended integrated schools (Ravitch, 1983). Therefore, subsequent changes in the SAT averages could not readily be attributed to the effects of integration.

Nevertheless, the SAT scores continued to decline, and at a more rapid pace (Figure 16). Part of the reason for this decline was due to new demographic trends. Beginning in 1971, there was an unprecedented drop in public school enrollment (*Statistical Abstracts of the United States*, 1990; *The Condition of Education*, 1984). As the last members of the "baby boom" generation passed through the public schools, the numbers of White students and Black students began to decline. At the same time, Asian and Hispanic immigration to the United States increased. Consequently, the proportion of minority students enrolled in public schools rose from 24% in 1976 to nearly 30% in 1984 (*Condition of Education*, 1987). The changing demographic composition of public schools between 1976 and 1986 is shown in Table 12.

The increased proportion of minority enrollments in public schools was responsible for much of the decline in the aggregate SAT-M during the first half of the 1970s. As the table shows, most minority groups have a lower average SAT-M score compared to aggregate score. For this reason, the statistical definition of the contributions of the various student groups to the declines of the SAT-M scores prior to 1976 cannot be determined since ethnic data were not collected on SAT test takers prior to this time.

Although there is very little data on SAT data on student racial/ethnic breakdowns prior to 1976, it is possible to make one conclusion about the trend in the aggregate scores between 1963 and 1976. The conclusion is that changing student



demographics, not changes in the quality of teachers or curricula, were responsible for the bulk of the decline in the SAT-M scores.

The racial and ethnic information provided by the College Board is valuable in evaluating the effects of differences in the trends of the various student groups. For example, between 1976 and 1978, SAT-M scores declined for Puerto Rican, Mexican-American, American Indian, White, and Asian-American students.

TABLE 12

RACIAL/ETHNIC ENROLLMENTS IN PUBLIC ELEMENTARY  
AND SECONDARY SCHOOLS: 1976, 1984, 1986

RACE/ETHNICITY	YEAR			PERCENT CHANGE 1976-1986
	1976	1984	1986	
	Enrollment in thousands (% total enrollment)			
Total	43,714 (100)	39,452 (100)	41,156 (100)	-5.9
White	33,229 (76.0)	28,106 (71.2)	28,957 (70.4)	-12.9
Total Minority	10,485 (24.0)	11,346 (28.8)	12,200 (29.6)	16.4
Black	6,774 (15.5)	6,389 (16.2)	6,622 (16.1)	-2.2
Hispanic	2,807 (6.4)	3,599 (9.1)	4,064 (9.9)	44.7
Asian	535 (1.2)	994 (2.5)	1,158 (2.8)	116.4
Native Amer.	368 (0.8)	364 (0.9)	356 (0.9)	-3.3
Source: <i>The Condition of Education</i> , 1989				

The only exception was the scoring patterns of Black students, which increased in 1977, but then fell back to the 1976 level in 1978. The fact that nearly every racial/ethnic group experienced the decline strongly suggests that demographic changes could not account for all of these declines. The justification for this statement can be found in Table 12. As shown in the table, between 1976 and 1986 enrollments were nearly unchanged for Black students (-2.2%) and American Indian/Alaskan Native students (-3.3). The declines in enrollments of White students were much greater (-12.9%). At the other extreme, enrollments of Hispanic students increased by 45% and enrollments of Asian/Pacific Islander students increased by 116%.

If the changes in student scores were principally due to changes in enrollments, then certainly the declines in the scores of Hispanic and Asian students could be explained by increased immigration, since many immigrating students are temporarily disadvantaged because of language differences. Increased numbers of immigrants could explain the declines in these particular student groups between 1976 and 1978.

Black and Indian-American enrollments were stable, and White enrollments actually continued to decline between 1976 and 1978. Therefore some other factor must be the cause of the score declines for these student groups.

The College Board (1977) recognized the global nature of the declines when it reported a

. . .pervasive score decline--in the sense that it showed up within virtually all categories of SAT takers. . .among students at the higher



and those at the lower percentiles of their high school classes, among students in private and in public schools, among those in large and in small high schools, among those taking 'academic' and those taking 'career' courses of study in high school, among test takers from high- and from low-income families, among men and women, among white students and from those from minority groups, among students expecting to go on to different kinds of colleges, among those intending to take postgraduate work and those looking only toward a baccalaureate. (p. 20)

The global nature of the scores declines for nearly all student groups regardless of enrollment patterns suggests that some change in school goals might be related to the declining scores.

The hypothesis that changes in school goals could be related to the declines in student achievement is further supported by two other research findings. First, the nearly universal declines in science achievement occurred at the same time as the educational funds from ESEA and the Bilingual Education Act were producing greater numbers of teachers and new specialized programs for disadvantaged students. Second, because of declining enrollments, the student-teacher ratio declined in the 1970s (*Digest of Education Statistics*, 1980). These two educational changes should have helped to improve student achievement. Apparently, any benefits due to better student-teacher ratios, bilingual programs, and programs for disadvantaged students were outweighed by other changes in the school goals or in student characteristics, such as motivation, which was discussed previously in Chapter 5.

By 1975 the "Back-to-Basics" movement was well under way. Schools had begun to offer fewer electives, emphasizing instead English, social studies, science, and mathematics. Therefore, it was not unexpected that the SAT-M scores should



begin to rise among various student groups as early as 1978. The expectation would have been that the scores of White, Indian, and Black students should have risen the most, since the student populations for these groups were fairly stable. The scores of Black and American Indian students did increase as expected. The scores of White students, however, did not rise, and continued instead to decline. The declining SAT-M for White students suggested that some other characteristic of White students might be related to their score declines.

Between 1976 and 1980, in spite of continued declines in enrollment of White students, scores for this student group declined by 9 points. In comparison, scores of both Black and Indian students, whose enrollments also declined, rose by 6 points. The uncharacteristic trend in the scores of White students is further illustrated by the fact that these declines exceeded those of Puerto Rican students (-7 points) and equalled those of Asian students, whose enrollments were being enlarged by immigration. Furthermore, the scores of Mexican students rose 3 points during this same period. The rise in the Mexican scores suggests that the combination of different student characteristics and compensatory educational programs were able to cancel out the negative effects due to continued immigration.

### **1980s: The Failures of the "Excellence" Reforms**

By 1978 a new trend became apparent as the SAT-M scores for nearly all student groups began to increase. In accordance with the time-lag hypothesis, the trend began three to 4 years after the onset of the "Back-to-Basics" movement. There was, however, one exception to this trend. Scores for White students did not



begin to recover until 1983, nearly 5 years after all other minority group trends had reversed.

The sharp rise in SAT-M scores between 1981 and 1985 most probably reflected the continued momentum of the "Back-to-Basics" reforms with the emphasis on core courses in science, mathematics, and reading. The continued improvement after this time may have also reflected the effects of the "Excellence" reforms spawned by the commission reports. This interpretation is based upon the fact that the average SAT-M scores increased for every student group during this period. Since the scores for all student groups increased, it is likely that the cause was due to a global change in the learning environment.

The scores for Asian students, whose scores averages are the highest of any student groups and the scores for the other student groups whose scores were lower than for White students all improved throughout the 1980s. For each of these student groups, their 1990 SAT-M average was higher than in 1976. This universal improvement again suggests that the learning environment had continued to improve.

The scoring trend for White students during the 1980s was again distinctly different from the other student groups. The first difference was that after 1985, the average SAT-M scores of White students remained nearly unchanged, while the scores of all other student groups continued to increase. The second difference was that every student group, except White students, scored higher in 1990 than in 1976 on the SAT-M. Black students, for example, raised their scores by 31 points and the scores of Mexican students increased by 20 points during this time. Not far behind,



the scores of American Indians increased by 17 points. Though less dramatic, the scores of Asian students increased by 10 points, reaching 528, which is 26 points higher than the aggregate average in 1963.

The net loss of 2 points in the SAT-M scores for White students between 1976 and 1990 in the face of 14 years of educational reforms is evidence that some characteristics of this student group have changed in a way to negate the effects of better schools. The distinction between the trend for White students is even more apparent when one considers that the gains by the Hispanic and Asian students occurred during periods of large increases in the student populations of these groups due to immigration. If the scoring trends of White students between 1976 and 1990 are compared against those of Black and Indian students, whose enrollments were fairly stable, the differences is dramatic. The gains by Blacks outpaced White students by 33 points; the gains by Indian students exceeded those of White students by 19 points.

At the close of the decade, the Asian students had widened their lead over White students on the SAT-M; and every other minority group had closed the gap between their scores and those of White students. This trend again suggests that there was some difference in the characteristics of White students that have resisted the continuing effects of the education reforms.

The NAEP trends are very similar to those of the SAT. Like the SAT, the NAEP trends revealed a pattern of decline in the 1970s followed by a recovery in the 1980s. In addition, the NAEP results show that declines for both White and Black



students began prior to 1973. In a similar fashion, there was a decline in the achievement scores for White students between 1970 and 1986 for both 13- and 17-year-olds. In comparison, the scores of 13-year-old Black students improved by 7 points over the same period. The scores for 17-year-old Black students did decline, but only about one-third as much as for 17-year-old White students.

The trends in the SAT-M and NAEP scores both show that the achievement all of the minority groups has improved significantly, while the achievement of White students is generally lower in 1990 than in the past. The scores of White students have not responded to the efforts of a decade and a half of educational reforms.

### **Declines in Science Achievement: An Alternative Hypothesis**

Both the trends of the SAT-M and the NAEP tests support the hypothesis that some characteristic of the White student population has been immune to the effects of the educational reforms that have resulted in improved achievement for all other student groups.

This assumption is also consistent with the changing goals of public schools since 1958, as described in Chapter 5. The Civil Rights movement, the Vietnam War protests, and changes in the characteristics of students and their families all helped to alter school goals and to lower student motivation. As these influences reached into the schools, the primary concern with academic excellence was replaced by the view that each and every student needed to experience individual success.

During the 1960s, the Neo-Thomist philosophy, which stressed reading, memorization, individual competition for grades, the authority of the teacher, and

preparation of the most able students for college was rapidly replaced. Increasingly, educators embraced the philosophy of Carl Rogers, which stressed the individual and cooperation among pupils instead of competition (Rogers, 1969, 1971, 1983). In the Rogerian approach to education, the Neo-Thomist authoritarian teacher was replaced by a facilitator, and the curriculum no longer taught any truths with a capital "T." The yardstick for the worth of any curriculum became its usefulness in relation to the needs of the students. The Rogerian saw the source of educational energy residing in the child. The task for the Rogerian teacher was to tap this energy and to guide it, rather than forcing it to flow in some prescribed direction established by the school or the teacher.

The climate of the 1960s was a fertile ground for the Rogerian educators. Many educators adopted A.S. Neill's philosophy that students know best what they need to learn and when they need to learn it. This Romantic "noble savage" belief that students were the best judges of what knowledge was of most worth became a major force in the American educational institutions during the late 1960s.

In prior years, the teacher was assumed to know best what the student needed. The primary purpose of school was to learn; and science, mathematics, history, and language were deemed to have an intrinsic value without having to justify their utility to the individual. Student success was measured by the degree to which the material



was mastered as evidenced by test scores, and promotion or failure, as well as student self-worth, was determined on the basis of these scores.

The Rogerian movement was in part a reaction to the weaknesses of the Neo-Thomist approach to education. Few educators advocate returning to the strict discipline and faculty psychology practices of earlier times. One problem with the Rogerian philosophy, as adopted by schools in the United States during the 1960s, was that it was mutated by societal forces during a period of traumatic social and political unrest. A second problem was that the Rogerian philosophical principles were often not clearly understood, and therefore incorrectly implemented, by classroom teachers.

As it was initially envisioned, the Rogerian approach to education was not inconsistent with the goal of high academic achievement. The Rogerian educators simply planned to measure student achievement in terms of the individual student, rather than in terms of an absolute standard based upon mastery of content.

When the nation became sensitized to any form of discrimination in response to the Civil Rights movement, the Rogerian emphasis on the individual student and group participation seemed particularly attractive. In the quest to achieve social equity, school practices that favored gifted students came to be viewed as elitist since often disadvantaged students were disproportionately excluded from such programs (Dixon, 1982; Smith, 1985; Howley, 1986; Metz, 1990). For this reason, much of the emphasis on courses of study that fostered scientific excellence was discontinued (LebBlanc & Verner, 1981). The idea was that less able students would benefit from

being exposed to more capable students and that the more capable students would develop fewer feelings of superiority.

The Rogerians did introduce two very new goals for schools. The first was the idea that students needed to succeed and that student success was the responsibility of school. The shifting of responsibility from the parent and the student to the school system was in accord with the societal agenda to promote educational equity. The notion that students need to succeed led to two new educational practices: social promotion and grade inflation. Eventually, the concept of school responsibility for student success was expanded to the extent that student failure became unacceptable (Adler, 1983). In many school systems throughout the country, the failure of any student came to be viewed as the failure of the system and not the child.

Social promotion was also related to the drive that began in the 1960s to reduce the dropout rate. One way to keep students from failing out of school or to quit because they were older than their peers and felt out of place was to pass them. Eventually, retention in the same grade level came to be viewed almost as a form of child abuse (Lange, personal communication, April, 1988).

Social promotion, social achievement (grades based upon ability, rather than achievement), and the social disruption of the 1960s probably contributed to the grade inflation of the 1970s. During this time, when the SAT and NAEP scores were



declining and the numbers of remedial college courses were increasing, high school grade point averages showed a steady rise.

The College Board (1977) suggested that changes in school goals could be related to declines in the SAT-M scores. According to the report,

Schools may have tried so hard to accommodate the special needs of new and unfamiliar students that these very students along with others have been ill served by not being held to demanding expectations of performance. The lowering of teaching sights is the wrong answer to whatever may have been the consequences of the expansion and extension of educational opportunity. (p. 47)

The Board cited permissive school attitudes toward increased student absenteeism, social promotions, and grade inflation. The Board also mentioned reductions in the amount of required homework, the lowering of readability levels of textbooks, the lowering of college entrance standards, and the advent of remedial college courses, as evidence of lowered standards related to changes in educational goals.

Even though the goals of social equity and dropout prevention were driving forces, they were not the only factors that led to the alteration of school goals. The events of the 1960s, which were described in Chapter 6, caused educators to begin to lose much of their authority to control academic standards. The loss was further exacerbated because the Rogerian movement had conferred much of the authority for what a student learns onto the student and thereby to the parent, while the schools, in turn, became responsible for ensuring that the students were successful. Since parents now had a legitimate role in evaluating the curricula and setting academic standards, the authority of educators to set academic standards was diminished (Kirst, 1984b). This transformation of school goal shifted the



responsibility for student success from students and parents to teachers, and the control over the curricula was shifted from the teacher to students and parents.

When educators lost the power to set absolute standards by which student mastery was measured, it became possible for students and parents to dictate the standards. As Kirst pointed out, increasingly instruction had become directed not by the teachers, but by community pressures. As the characteristics of the students and the families changed in recent decades, the stage was set for a conflict between the goals of educators and the goals of the public. Because much of the authority to set standards had been taken from schools, they were ill equipped to resist these societal pressures. Chubb (1988) studied the relationship between school autonomy in determining academic matters and student achievement. He found that students in autonomous schools learned at least more than students in comparable schools controlled by politicians and administrators in a central office.

Still another factor that contributed to diminished emphasis on academic standards was the expansion of school goals to provide services that in the past had been the responsibility of the family and the community. According to David Tyack (cited in Kirst, 1984) schools now provide

lunches, dental and medical inspections, nursing care, physical education, health classes, playgrounds and recreation, psychological counseling and mental health facilities, student government and extracurricular activities... vocational courses and vocational guidance. Dozens of new positions appeared as a result of this specialization and extension of functions: teachers of driver education, home economics, or sheet metal work; counselors, curriculum or disciplinary vice-principals; school social workers; dieticians and lunchroom workers; nurses; social activity directors and many others. (p. 49)



Mortimer Adler (1982) called for a narrowing of school goals. Adler proposed Paideia schools--schools with "general, nonspecialized schooling" in which tracking, electives, and vocational training were eliminated. Paideia schools would stress the classics and would teach students the "skills of learning."

The ever widening scope of school goals and the rapid shifts in these goals in response to changing societal conditions served to lessen the focus on science achievement. Each of these factors--suddenly widening and rapidly shifting school goals, and changing characteristics of students and the American family--contributed to the reduction in the ability of teachers to control the educational process.

Changes in student motivation were cited by the College Board (1977) and the National Assessment of Educational Progress (1988) as possible causes for the declines in science achievement. Further evidence was cited by Rock et al. (1985) who reported that increased percentages of students were enrolling in general rather than academic programs of study.

The results of the National Assessment of Educational Progress (1988) study also indicated that the amount of laboratory work, the types of classroom activities, and the extent of parental involvement in school affairs appeared to be much less influential determining science achievement than was the level of student motivation.

Differences in student levels of motivation may also account for the discrepancies between the SAT-M trends for the various student ethnic and racial groups that were discussed earlier in this chapter. For example, the weakening of motivation on the part of White students during the 1970s and 1980s can be related



to lower achievement since the responsibility for determining achievement levels had been shifted from the teacher to students. In this regard, Rock et al. (1985) reported that the largest declines in student achievement between 1972 and 1980 were for middle class, social-economic status White students.

At the other end of the motivational spectrum, Asian students tend to be more highly motivated because of strong family values that set high achievement standards. The continued improvement of Asian students suggests that the curriculum and the teachers have not been impediments to improved achievement for this student group.

The hypothesis that changes in student motivation are linked to the declines in student achievement can also account for the trends in the achievement scores of the other minority student groups. One of the effects of ESEA and the Bilingual Education Act was to implement programs to improve the motivational level and study skills of disadvantaged students since these skills were often not taught within their family environments. Because of the realization of past social injustices to African Americans, programs to overcome social handicaps were especially targeted at Black students. Another reason why Black students may have shown increased motivational levels in recent years is that the opportunities for Black graduates in both work and college opportunities are so great (National Science Board, 1989). The large gains by Black students fit very well with this model.

The model of student achievement presented in Chapter 3 involved the teacher, the student, and the curricula, and school goals in the learning process. What the model failed to include was the fact that each of these factors in turn are



influenced by, and to a large extent are the products of, the context of American society in which they exist. The model shown in Figure 18 includes these external influences on the school learning environment. Kirst (1984a) said, "The American people control the system of education in the United States and they get what they want." (p. 11)

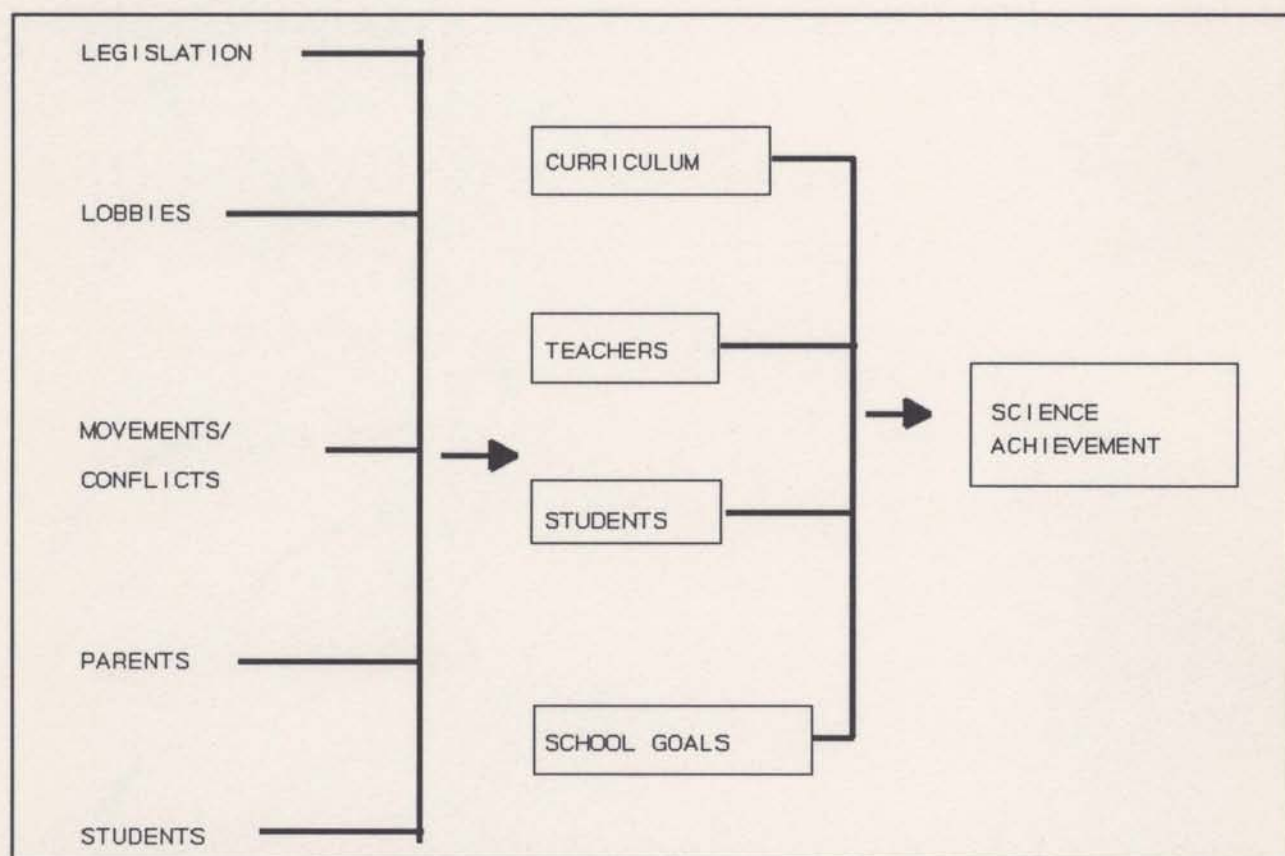


Figure 18. A Model of Some Major Influences on Student Achievement in Science

In conclusion, the hypothesis that has been developed from this research is that (a) the recent declines in science achievement are most likely due to changes in student characteristics and motivation, (b) to changes in school goals, and (c) to changes in the school autonomy, which has caused schools to lose control over

academic standards. The research does not support the hypothesis that changes in teachers or curricula were related to the declines in student achievement.

This hypothesis leads to proposed educational solutions that are very different from those proposed by the recent commissions and being implemented by state and local school districts. In the last chapter, implications of this model are discussed and some recommendations for educational reforms that could be expected to improve student achievement are proposed.



## **CHAPTER 8**

### **IMPLICATIONS AND RECOMMENDATIONS FOR PUBLIC SCHOOLS**

If we assume that the declines in science achievement are related to changes in student motivation, school goals, and school autonomy; then many of the proposed educational reforms are unlikely to result in higher student science achievement.

#### **Educational Reforms--Predicting Winners and Losers**

The findings of this research report suggest that three classes of educational reforms are likely to result in improved student achievement in science. The first class involves reforms that raise student motivation. The second class includes reforms that shift school goals in favor of more rigorous achievement standards. The third class encompasses reforms that increase school autonomy in the area of setting standards of achievement.

The findings also suggest that other reforms should have much smaller positive effects or even negative effects on student achievement. Specifically, reforms aimed at improving teachers or curricula should have much smaller positive effects on student achievement. On the negative side, reforms that reduce school autonomy, as well as reforms that conflict with school goals that promote student achievement, should have a strong negative influence on student science achievement.

In this next section, the above criteria are used to predict the expected effectiveness of some recent educational reforms on student achievement.

### **Teacher Quality**

Most of the states followed the recommendations of the commission reports in raising teacher salaries and many instituted merit pay. Nevertheless, higher salaries, career ladders, teacher recognition, mentor teachers, and teaching fellowships, although needed to attract and retain qualified teachers, should not result in improved student achievement. As has been shown in Chapter 5, improved teacher quality during the 1970s and 1980s was not able to compensate for the negative effects of other influences on student science achievement.

A second teacher reform that has been implemented in many states is teacher competency testing. Competency testing also should not have a large effect in raising student achievement. Since teacher quality has not been the cause of the recent declines in achievement, teacher testing should have little impact on achievement.

Although further improving already competent teachers should not result in significant gains in student achievement, declines in teacher quality should result in significantly lower overall student achievement. The reason for this seeming inconsistency is that even highly motivated students could not maintain high levels of achievement if they did not have access to the information, which is provided by



qualified teachers. Therefore, the reforms aimed at maintaining or improving teacher quality are essential to prevent further sharp declines in student achievement.

One teacher reform that should result in improved student achievement is performance-based pay. If teacher salaries are tied to student achievement, then teachers will be encouraged to raise standards for student achievement. An interesting point about this reform is that the increases in student achievement will result not because of better teaching, but because higher standards are required. Schools could achieve the same effect without having to institute "merit pay" by simply establishing and enforcing school goals that demand higher achievement.

A second reform that should be expected to raise student achievement is teacher empowerment. If teachers were given the authority to set school standards for achievement and these standards were then supported by the administration and the school board, then dramatic improvements in student achievement could result. This particular reform, however, has not been widely implemented in schools, and teachers continue to be excluded from involvement in deciding policies for promotion and retention. Ernest Boyer, President of the Carnegie Foundation, in the foreword to the Carnegie Foundation report, *The Condition of Education* (1990) said,

. . .when it comes to crucial decision making, teachers are often left out. While the majority do participate in such matters as choosing textbooks, they are not significantly involved in setting student promotion and retention policies at their school. I find it especially disturbing that teachers report a sharp decline in the control they feel they have over their professional lives. (p.v)

## Curricula Reforms

The same reasoning that applied to the effectiveness of teacher reforms in improving student science achievement applies to curricular reforms. Proposals to completely restructure the curricula in a neo-NDEA fashion should not result in higher student achievement. Similarly, programs to develop curricula to promote higher-order thinking skills have to date not demonstrated their effectiveness in the NAEP tests (Mullis & Jenkins, 1988). In the same way, proposals to integrate the curricula, to provide for more science laboratory activities, and to downplay teacher lectures in favor of other instructional strategies, should be expected to have little effect on student science achievement. The reason for this departure from the NDEA solution for poor science achievement is that the source of the problems are different. The causes of the Sputnik educational crisis were the science curricula and poorly trained science teachers. The cause of the current crisis, however, is not the curriculum or teachers. On the contrary, each of these two factors have blunted an otherwise even steeper drop in student achievement in science.

As was true with teachers, the inverse of this argument is not valid. Any reform that causes the curricula quality to decline should result in lower student achievement because students will not have access to essential information. Therefore, although recent curricula reforms cannot be expected to improve student achievement significantly, these reforms are essential to maintain the quality of the



curricula, which in turn will help to prevent further sharp declines in student achievement.

One curricular reform that should result in higher student science achievement, however, is the move to strengthen science textbooks. Because teachers rely to a great extent on the textbook, textbook quality has a great effect on the information that the student receives.

Much has been written about the "dumbing down" of textbooks that occurred during the 1970s (DeSilva, 1985). Although textbooks have been upgraded somewhat during the 1980s, it is very difficult for a science publisher to sell a high-quality, rigorous textbook. For example, many adoption states set requirements that dictate low readability levels for textbooks. State adoption committees, religious groups, feminist organizations, and racial/ethnic groups exert a strong censoring effect on textbooks. Also, the various special-interest groups often pressure such committees to exclude any content that these groups find offensive.

Because adoption states represent a sizable guaranteed income for publishers whose texts are adopted, these various forces can exert a great deal of pressure on publishers. Therefore, the likelihood of textbooks improving significantly in the next few years depends to a large extent on the societal factors that determine the thrust of the various state adoption committees.

### **Dropout Prevention**

Can schools develop policies to keep at-risk students from dropping out and at the same time improve student achievement in science? There is not conceptual

incongruity with these two educational goals. The seeming incompatibility has developed at the level of school objectives, which are the translation of school goals into administrative policies.

Any of the dropout policies that lower academic requirements as a means to lower the dropout rate are incompatible with goals for higher science achievement. However, the conflict is at the policy level. By allowing students to pass courses and to proceed to the next grade without having mastered the material, schools send a clear message that high standards are not necessary to succeed. Furthermore, this policy communicates to the other students that minimal efforts are adequate to succeed.

It would seem that it is possible to develop programs that can help keep at-risk students in school without lowering standards. Such programs would help to develop student motivation and to provide remedial training in fundamental skills of reading, writing, and mathematics. This approach is expensive, requiring remedial teachers in a variety of subjects. The approach is also time-consuming, requiring remedial teachers to coordinate with classroom teachers. The alternative of simply keeping students from dropping out does little to provide them with the essential skills needed to succeed in tomorrow's world.

### **Graduation Requirements**

Those reforms that raise student achievement levels required to get passing grades, to be promoted, or to graduate should result in higher student achievement. Therefore, the state reforms that raise course standards or graduation requirements



should result in higher student achievement. Similarly, athletic or extracurricular policies that demand higher student achievement will also result in higher student achievement.

A problem that schools have encountered in trying to implement such policies is that they conflict with other policies to reduce the number of dropouts and to establish racial/ethnic equity in achievement. The policy of social promotion, although it may keep students from dropping out of school, is contrary to efforts to improve academic achievement. As long as promotion is not contingent upon successfully meeting a certain level of mastery of the subject matter, schools will be hard pressed to enforce the tougher graduation requirements. What will happen instead is that the course standards will continue to be lowered so that nearly all students can pass regardless of effort or achievement.

In much the same way, reforms that require student competency testing should lead to higher student achievement, if the passing scores indicate a meaningful level of achievement. By the end of 1988, 40 states had initiated minimum competency testing (Digest of Education Statistics, 1989 [p. 145]), and 19 states required students to pass a competency test to graduate from high school (*Education Indicators*, 1989 [p.68]).

It would appear from the results of the recent science achievement tests that student competency testing has not been all that successful in improving student achievement. For competency testing to have meaning, passing scores must be linked to satisfactory mastery of the curricula. On the other hand, if the passing scores are

set too low (e.g., minimum competency tests), or if the test material is so basic that all students can pass, then competency testing will not have a very positive effect on student science.

One of the road blocks facing reform efforts that involve student testing is that the testing fails larger proportions of minority students compared to the overall student population. Therefore, the testing is often attacked as being in conflict with school goals to promote social equity and to prevent students from dropping out. For example, in 1989 the State of Florida raised the passing score its College Level Academic Skills Test (CLAST) test, which is required to graduate from junior colleges and to enter upper level courses at the state universities. As a result fewer students passed the test. The percentage of White students passing the test dropped from 88% to 75%. The percentage of Blacks passing dropped from 56% to 42%; and the percentage of Hispanics passing dropped from 67% to 42%.

The new standards were immediately challenged. The NAACP charged that the tests were unfair and arbitrary for minority students, based upon the fact that they had lower passing rate than White students (Oliver, 1990). The NAACP response to the CLAST demonstrates the degree to which setting standards has been removed from the realm of education.

The College Board's SAT has been attacked on similar grounds. As a College Board staff member said to this author, "It is a little like shooting the messenger who brings the unpleasant news." Nevertheless, the SAT has developed a modified test that is scheduled to replace the traditional SAT test within the next few years. And



yet, even before the test has been unveiled, different groups have challenged the College Board's intention to include a writing section as being unfair to minority groups.

### **Parental Involvement**

Virtually all of the recent educational reform reports call for greater involvement of parents in the education process. According to the Gallup Poll (1990), a majority of the general public believes that parents should have more control over the allocation of school funds and over the curriculum. More than 40% of the respondents believed that parents should also have a greater say in the selection and hiring of teachers and administrators, as well as a greater voice in the selection of books and instructional materials. Can we expect that parental control over funding, hiring of teachers, and curricula to improve student achievement? Probably not. Such involvement is more likely to have a very strong negative effect on student achievement. The reason why this type of parental involvement could have a negative influence is that it can serve to further weaken school autonomy in setting academic standards.

On the other hand, parental involvement can improve science achievement if the involvement involves supporting school goals, working with students to improve student motivation, or working to alter school goals in the direction of higher standards of achievement.

One example of parental involvement that should lead to declines in student achievement is found in the Chicago school system. This plan, begun in the fall of

1988, was a response to the charge that the school bureaucracy was responsible for the educational ills of the Chicago schools. It was felt that by turning control of the schools over to parent councils, it might be possible to lower the city's 41% dropout rate and to raise SAT scores (Tifft, 1990).

The plan called for school decentralization that transferred control of its 541 schools from the Board of Education to locally elected councils. Each council was composed of six parents, two community representatives, two teachers, and an ex officio member, the school principal. The councils were empowered to hire and fire principals, to approve budgets, and to develop plans to improve student performance (Tifft, 1990).

Because the Chicago plan shifts control of the learning climate farther away from teachers and because the plan also places additional limitations on the ability of educators to control standards of achievement, this reform plan should have a serious negative effect on student science achievement.

### **School Accountability**

School accountability should have some slight positive effect on student achievement. The effect should only be slight because making schools accountable for student achievement without giving them autonomy needed to enforce high academic standards cannot be very effective. One way that schools might accommodate these requirements is to teach to the competency tests. In a number of school systems, teacher and principals have already been accused of altering student test answers or changing student scores. School accountability can have a



very positive effect on achievement, but only if it is accompanied by increased autonomy in the area of academic standards.

### **Schools of Choice**

Schools of choice allow parents and students to decide which school the students will attend. Referring to such schools, President Reagan said, "Choice works and it works with a vengeance" (Paulu, 1989). (p. 1) According to Paulu, schools of choice can

1. Change the structure of public education
2. Recognize individuality
3. Foster competition and accountability
4. Improve educational outcomes
5. Keep potential dropouts in school and draw back students who have already dropped out.

Schools of choice should raise student achievement, but not for the reasons listed above. To suggest that public education does not recognize individuality or that public schools do not try to keep potential dropouts in school is to ignore three decades of educational reforms and programs aimed at the individual student and the at-risk student.

What schools of choice do offer are (a) greater autonomy for the school and (b) greater incentives for improved student motivation. The very fact that a student chooses a school makes the school special to that student, which gives the student a greater incentive to stay in school. Similarly, if the student does not meet the school

requirements then the ability of the school to remove that student from its rolls provides the school with the autonomy needed to maintain academic goals and standards.

The success of Catholic schools and other private schools in outperforming public schools is due in part to the element of choice on the part of the student and the school. In such schools, the student knows that if he or she does not pass, he or she can fail out of the school.

The importance of choice, school autonomy, and high standards in raising student achievement are also demonstrated by the recent successes of Black students majoring in science and mathematics at Xavier University. Xavier, which is in New Orleans, only requires a combined mathematics/verbal score of 700 on the SATs. Yet, according to Toch (1990), 47% of Xavier students graduate with science and mathematics degrees, compared to the national average which is 7%. Furthermore, in recent years 20% of Xavier graduates were accepted in medical or dental schools.

What is the secret of this small college with 2,058 undergraduate students, 92% of which are Black? The school is not highly endowed, the science laboratories are not filled with high-priced, high-tech equipment. What the school does have is a well established program to motivate students--a program that begins in grade 11 with special summer camps. Also the school sets high standards of achievement that



must be met. According to Toch (1990), 25% of the freshmen class drops out and another 25% of the students take 5 years to graduate.

It would seem that schools of choice can be very successful. On the other hand, traditional public schools could achieve similar successes if their previous autonomy and commitment to student achievement were restored.

### **Year-round Schools**

Another educational reform that should only have very small effects on achievement is increased school time. Longer school days or a longer school year, or both, will only keep students in school longer. Weiss (1985) is convinced that a longer school day/year will not itself increase student achievement. Instead, she maintains that:

Student cultures are rather, semi-autonomous and, as such, cannot be controlled easily or directly. They arise in relation to structural conditions in the larger society and the way in which these conditions are mediated by both the experience of schooling and the lived experiences of youth in their own communities. None of the proposals for reform address these issues. (pp. 218-219)

Students now spend more time in school than at any other time in our nation's history. The amount of time spent learning is not the problem. Simply keeping low motivated students in school will most likely have little effect on student achievement. It would be equally beneficial and much less expensive to simply have students learn

more in less time. Again, this can be accomplished by increasing student motivation and demanding higher achievement levels.

### **Corporate Partnerships**

Some of the proposed educational reforms have suggested forging ties between businesses and public schools. Such partnership might involve administrative training of school personnel. The partnerships could also be used to provide speakers, counselors, and advisory councils for schools, as well as summer jobs for students.

Corporate partnerships should raise student achievement, if the reforms concentrate on raising student motivation. Although as schools have already found out, it is not that easy to change student attitudes and characteristics. The level of success of such partnerships will depend upon the extent to which they improve student motivation and raise student achievement.

### **Summary and Conclusions**

Teachers today know better how to teach than their predecessors three decades ago. Today's schools are modern marvels with closed circuit television stations, computer laboratories, and sophisticated science laboratories. And yet, by nearly every measure, American public schools are no longer as effective in teaching science as they were in the past. Three decades of educational innovation have not been able to restore science achievement to 1960s levels.

A large part of the reason that schools have been unable to raise science achievement significantly is that public education has been faced with a seeming



paradox. On one hand schools have been charged with lowering student dropout rates and ensuring that all students succeed. On the other hand, schools are told that they must produce the best science students in the world.

Because of these disparate goals, there has been little agreement as to the appropriate educational solutions to the current crisis in science education. Part of the reason, for the lack of agreement is the fusion of the question of the equity with the issue of high achievement. Charges that high academic standards and competency tests unfairly discriminate against minority students have made educators and legislators extremely reluctant to engage in practices that could be viewed as racist. Bates (1990) maintains that any school policy or practice that results in racially identifiable outcomes is "second-generation segregation." According to Bates, the suspension rate for Black students, which is three times greater than for White students, suggests a form of discrimination. He also cites lower proportions of Black students in gifted programs and college-preparatory programs, and honor societies, and higher proportions of Black students in special education courses, as evidence of continued discrimination.

It can just as easily be argued that the present policy of benign neglect, which promotes students regardless of their academic merit, discriminates against all students. Low standards of achievement rob students of their right to reach their potential; to strive for high academic goals. And such a policy deprives the nation of the scientist, technicians, and scientifically literate populace that it so sorely needs

to compete in the world market and to maintain our standard of living and the quality of the environment.

The solution to the science crisis needs to address how to change school goals in a way that promotes science achievement, while helping all students to reach their maximum potential. We as a nation have tried all of the traditional solutions--stricter standards, more core courses, additional science and mathematics courses, competency testing, renewed emphasis on teaching higher order thinking skills, and a longer school day/year--and so far they have failed.

The art of teaching and the process of learning are well understood. If the sole goal of public education was simply to raise science achievement, the educational solutions would be simple. The formula for high levels of science achievement are well known. The ingredients are neither exotic nor mysterious, they are fairly simple and straight forward--good teachers, strong curricula, high standards for academic success, and motivated learners. Provide such a learning climate, and student science achievement will soar.

The problem facing schools is to raise science achievement without discriminating against at-risk students, many of whom are minority students. Any educational solution, in order to be effective, must address each of these problems. In order for schools to solve these problems, schools must first re-examine what are the goals of public schools. What do we want from our schools--academic excellence,



vocational education, patriotism, sex and health education, computer training, environmental awareness, critical thinking, character development?

We must recognize that schools in the 1990s are operating under an entirely different societal background that is unlike any other in our nation's history. Whereas during the first 50 years of this century, the principal concerns of teachers included gum chewing, talking, and throwing paper; teacher concerns of the 1980s included rape, robbery, assault, and murder (Metropolitan Life Insurance Company, 1988).

The little red school house has been replaced by large urban schools replete with armed guards, locked doors, and metal detectors to stem school violence. In 1990 the New York City School Chancellor, Joseph A. Fernandez backed the concept of police patrolled student only subway cars to protect students from escalating violence and in 1989, 784 children younger than 15 were arrested for assault (Berger, 1990). Apparently, the majority of Americans realize that schools are not all to blame for the declines in science achievement. In the 1990 Gallup Poll (Elman, 1990), for example, 73% of the public placed the blame on societal problems rather than on school performance.

Schools have not solved the racial, poverty, equity, or pollution problems; nor are schools fulfilling their academic mission. The first step in trying to reform schools is to redefine school goals. In 1893, the Committee of Ten, advocated the study of science, mathematics, history, and English, and foreign languages by all secondary school students. Yet, 25 years later the authors of the Cardinal Principles



recommended seven standards by which curriculum should be judged: health, fundamental processes, home membership, vocation, citizenship, leisure, ethics. These shifts in the direction of public education were so important that these events appear in nearly every history of education textbook.

By comparison the recent shifts in educational goals have become so frequent that before a new goal has time to become firmly established it is replaced by a new, often contradictory one. It is little wonder that teachers feel lost and not in control of their professional lives. Education is the only profession where the clients set the goals and the standards.

In regard to public education, Americans are ahistorical. Because Americans do not have a clear notion of the purpose of public education, in recent decades the direction of schooling has been changed abruptly in response to each new societal problem. The arguments concerning the purpose of public education have been circular, rather than linear. For example, the current espousement for critical thinking (Sternberg & Baron, 1985; Sternberg 1987; Sternberg & Martin, 1988) is in reality an echo of the same call by earlier educators such as Arthur Bestor (1955) who argued that the purpose of schools is to teach students how to think.

Perhaps, a voucher system that allows students to opt to attend any school, public or private, is the near-term solution to the science crisis. It seems unlikely given the current political and social climate that schools will be allowed to take the steps needed to raise achievement. The public are not willing to abdicate some of their control over schools. The only hope at this time for public education in the



United States may to entrust our young to private schools or schools of choice until such a time as the public school system will again be empowered to make itself fit.

In other areas of American life, people have made similar adjustments for the common good. For example, people have accepted airport searches, police roadblocks, and restrictions on the right to bear arms. Each of these adjustments were made in response to serious social threats, namely terrorist hijackings, drunk drivers, and rising crime rates and political assassinations.

Perhaps, when the public recognizes the seriousness of the current educational crisis, they will be willing to accept changes needed to restore science excellence to previous levels. The Roman historian, Livy, in his preface to *The History of Rome*, said, "...profecta ab exiguis initiis, crevrit eo ut jam laboret sua magnitudine<sup>1</sup>. This quote, which referred to the declining state of the Roman empire, might equally apply to the present state of public education in the United States.

### **Further Research**

The research examined the science achievement of public school students at the secondary level. Future research might investigate trends in science achievement at the elementary, middle, or postsecondary levels. Additional research might examine changes in science achievement of students in private schools. Finally, further research may wish to consider whether the trends in science achievement hold for other subjects or for student achievement in general.

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<sup>1</sup>having set out from small beginnings, it has increased to such an extent that it is now distressed by its own bulk

## **APPENDICES**



## APPENDIX A

# MEAN SAT-M SCORES

TABLE 13

Aggregate SAT-M SCORES: 1952-1990

YEAR	SCORE	YEAR	SCORE
1952	494	1972	484
1953	495	1973	481
1954	490	1974	480
1955	496	1975	472
1956	501	1976	472
1957	496	1977	470
1958	496	1978	468
1959	498	1979	467
1960	498	1980	466
1961	495	1981	466
1962	498	1982	467
1963	502	1983	468
1964	498	1984	471
1965	496	1985	475
1966	496	1986	475
1967	492	1987	476
1968	492	1988	476
1969	493	1989	476
1970	488	1990	476
1971	488		



TABLE 14  
SAT-M BY GENDER

YEAR	TOTAL	MALES	FEMALES
1967	492	514	467
1968	492	512	470
1969	493	513	470
1970	488	509	465
1971	488	507	466
1972	484	505	461
1973	481	502	460
1974	480	501	459
1975	472	495	449
1976	472	497	446
1977	470	497	445
1978	468	494	444
1979	467	493	443
1980	466	491	443
1981	466	492	443
1982	467	493	443
1983	468	493	445
1984	471	495	449
1985	475	499	452
1986	475	501	451
1987	476	500	453
1988	476	498	455
1989	476	500	454
1990	476	499	455

TABLE 15  
MEAN SAT-M SCORES BY RACE/ETHNIC GROUP

YR	ASIAN	BLACK	INDIAN	MEXICAN	PUERTO RICAN	WHITE
76	518	354	420	410	401	493
77	514	357	421	408	397	489
78	510	354	419	402	388	485
79	511	358	421	410	388	483
80	509	360	426	413	394	482
81	513	362	425	415	398	483
82	513	366	424	416	403	483
83	514	369	425	417	403	484
84	519	373	427	420	405	487
85	518	376	428	426	409	490
86	NOT AVAILABLE					
87	521	377	432	424	400	489
88	522	384	435	428	402	490
89	525	386	428	430	406	491
90	528	385	437	429	405	491



## **APPENDIX B**

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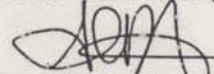
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